Preliminary Route Engineering Assessment of the

Stikine-Iskut

Transmission System

B.C. Hydro

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B.C. HYDRO

PRELIMINARY ROUTE ENGINEERING ASSESSMENT
OF THE
STIKINE-ISKUT TRANSMISSION SYSTEM

TRANSMISSION PROJECTS DIVISION

October 1982

ER47

Report No. TP 1040

PRELIMINARY ROUTE ENGINEERING ASSESSMENT

OF THE

STIKINE-ISKUT TRANSMISSION SYSTEM

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SUMMARY

In this route location report the feasible transmission line routes between the existing B.C. Hydro system and proposed hydroelectric generating stations on the Stikine and Iskut rivers and More Creek are identified and technically evaluated. Six transmission schemes are presented which would tie generation to the existing Skeena and/or Telkwa substations or to a new proposed station called Cluculz (which would be located approximately 50 km west of Prince George) or to a combination of these three stations.

The evaluation is based upon a 500 kV transmission system capable of transmitting the proposed generating capacity of 2765 MW with a first stage in-service date of 1993. If a transmission connection to a proposed Cluculz Station is chosen, a transmission voltage higher than 500 kV may be selected.

The report recommends a transmission system with one 500 kV transmission line to Skeena Substation and two 500 kV transmission lines to Telkwa Substation using routes situated generally near existing access. This system, as shown on Plate 6-1, generally follows the Iskut and Bell-Irving rivers to a point near Meziadin in the Nass River valley. From the Nass the route to Telkwa would use the valleys of the Cranberry and Kitseguecla rivers and remain west of Hudson Bay Mountain. The route to Skeena would use the valleys of the Tseax and Kitsumkalum rivers. This system should provide acceptable security of service and is estimated to be the most economical for both construction and maintenance with good available access along the routes.

SECTION 1.0 - INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this project was to determine and evaluate the feasible (acceptable) routes for a maximum of three high voltage transmission lines from proposed generating stations on the Stikine and Iskut rivers to the following three termination points:

1. The Skeena Substation near Terrace and
2. The Telkwa Substation near Smithers or
3. The proposed Cluculz Station (near Prince George)

This report is prepared as part of the preliminary planning report which is required for an Energy Project Certificate under the Utilities Commission Act. The investigation considers technical aspects of transmission line routes including design, construction, maintenance and security. Route segment cost estimates are made and used to identify the most economical routes for comparison. After technical, economic and security considerations are reviewed and evaluated, a recommendation of the preferred technical route alternatives for the high voltage transmission lines is made. No attempt is made to define the precise centreline alignment along the recommended routes.

1.2 BACKGROUND

Studies relating to the hydroelectric potential of the Stikine and Iskut rivers have been ongoing since 1964. Documentation of these studies and the identification of the proposed hydroelectric developments on the Stikine and Iskut rivers form part of the "Stikine - Iskut Hydroelectric

Development Feasibility Study" by B.C. Hydro, Report No. H1163, March 1980.

In 1978, B.C. Hydro undertook an overview study of northern transmission routes to link potential dam sites on the Stikine, Iskut and Liard rivers with the Lower Mainland and intermediate substations. Simultaneously, Ian Hayward and Associates Ltd. was commissioned by B.C. Hydro to conduct similar overview studies with emphasis not limited to technical matters but including environmental and socio-economic considerations. The results of the overview studies are documented in the following two reports.

1. "Northern Transmission Overview Study" by Ian Hayward and Associates Ltd., September 1979.

2. "Report on Northern Hydro Development Transmission Studies" by B.C. Hydro; Report No. SD 1020; October 1979.

Transmission systems associated with the hydroelectric development of the Stikine, Iskut and Liard rivers were subsequently divided into three sections namely: Stikine-Iskut, Liard-Cluculz and Cluculz-Creekside. This report, which addresses the Stikine-Iskut section, expands on the earlier studies to include feasible routes within the study area. A team of environmental consultants co-ordinated by Ian Hayward and Associates Ltd. were retained to assess the environmental and social impacts of the proposed alternative routes for the transmission system. Their studies were prepared concurrently with the route engineering studies and are reported in "The Preliminary Environmental and Social Impact Assessment of the Stikine-Iskut Transmission System".

1.3 STUDY AREA

Fig. 1-1 outlines the extent of the study area presented in this report. The four major physiographic regions encountered by the routes studied are: the Stikine Plateau, the Skeena Mountains, the Nass Basin and the Nechako Plateau which forms part of the Interior Plateau.

The Stikine Plateau is characterized by broad glacially scoured valleys and rolling upland plateaus. Forest cover on the plateau is scarce and characterized by clumps of spruce and willow. Modification of drainage has resulted from glaciation and numerous lakes occupy basins created in drift blocked valleys.

The Skeena Mountains extend from the Stikine Plateau 370 km south to Telkwa. They are very rugged and consist largely of folded sedimentary rocks. Folding has occurred in a northwesterly/southeasterly direction which accounts for the formation of the valleys. Three major valleys in this region which are of significance to the study are:

1. the Bell-Irving River valley,
2. the Nass River valley,
3. the Skeena River valley and its tributary valleys of the Kispiox, Kitwanga, Kitseguecla and Kitsumkalum rivers.

Valley floors range in elevation from 500 to 1200 m and are generally wide and drift-filled. The surrounding peaks are serrated and jagged as a result of cirque and valley glaciation.

The Nass Basin is an irregular shaped area of low relief and for the most part lies below 750 m elevation. Numerous lakes of glacial origin are evident. Many of the stream courses are parallel to northwestward trending drumlin-like forms also of glacial origin.

The Nass Basin is also characterized by recent volcanic activity at the head of Tseax River. Lava flows, as recent as 300 years, have dammed a tributary of the Tseax River, creating Lava Lake, and flowed to the south side of the Nass River forming a flat lava plain 11 km long by 5 km wide.

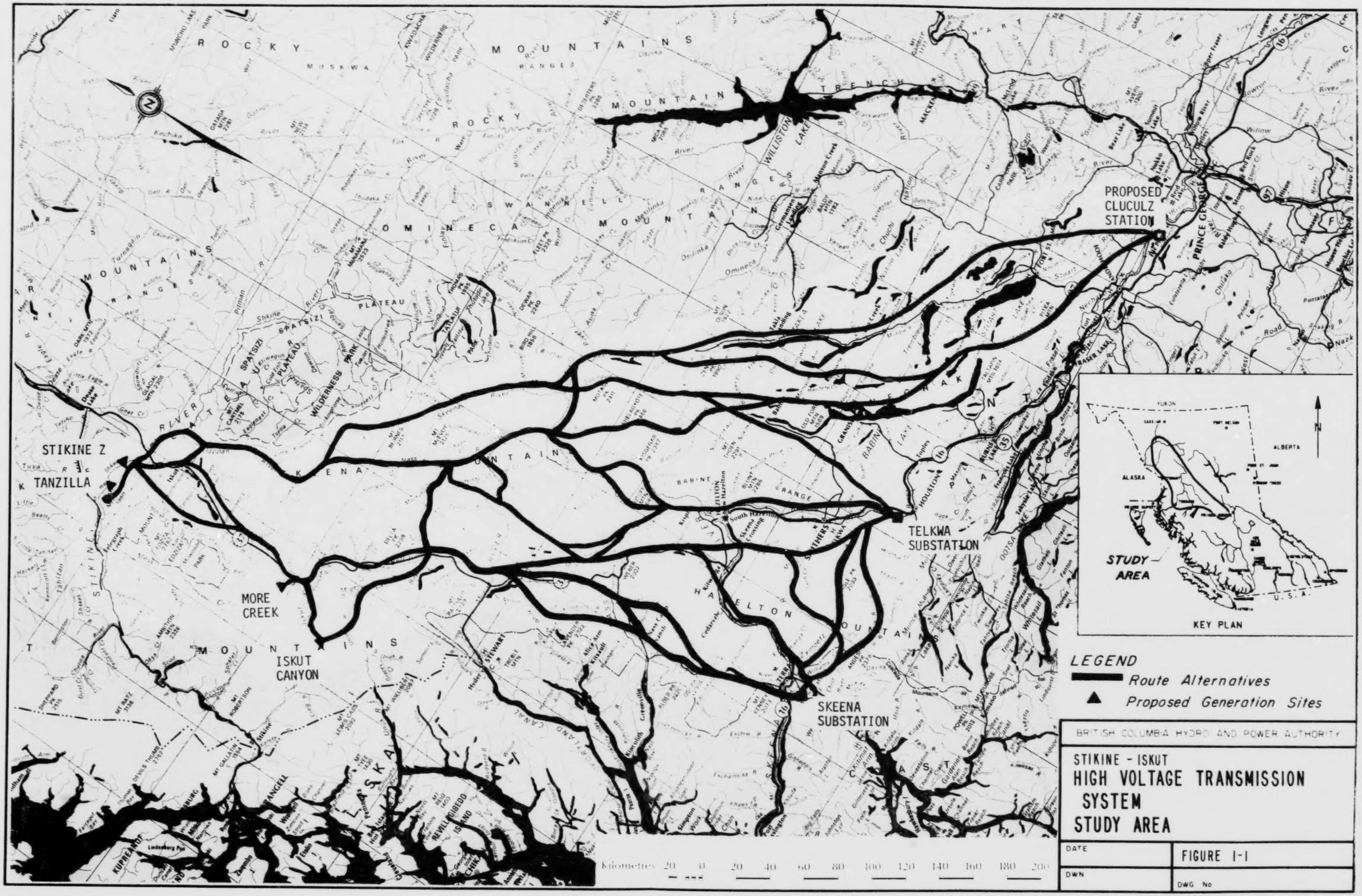
The Nechako Plateau is an area of low relief with great expanse of flat or gently rolling country. The plateau surface lies between 1200 and 1500 m elevation. Over much of the plateau, flat or gently dipping volcanic flows cover older volcanic and sedimentary rocks. Glacial drift is widespread and a high percentage of bedrock is obscured.

1.4 METHODOLOGY

Establishing preferred routes for the transmission system based upon engineering considerations involved defining feasible routes within the study area, the evaluation and comparison of these alternative routes and the selection of the preferred technical routes. The delineation of feasible routes is based primarily on physical and economic constraints. Physical features that preclude the construction of a transmission line are areas of extreme exposure due to high elevation, precipitous or unstable terrain, or areas of extreme insecurity due to slides or avalanches. Route segments that result in a transmission line of comparative excessive length are not considered due to the high construction and maintenance costs.

The study area was reviewed by map studies, a study of aerial photographs and field reconnaissance. The alternative routes were evaluated and compared on the basis of line lengths, estimated costs and line security. The preferred technical route is usually then selected. In the case of the Stikine-Iskut studies six transmission schemes involving alternate transmission line collector points and end points were possible. A preferred technical route alternative was identified for

each of these transmission schemes. From those six scheme alternatives a route was determined to best satisfy the engineering and security requirements.



LEGEND

Route Alternatives

Proposed Generation Sites

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
STUDY AREA

DATE	FIGURE 1-1
DWN	DWG No

SECTION 2.0 - PROJECT DETAILS

2.1 PRELIMINARY SCHEDULE

The preliminary schedule as presently proposed is shown on Fig. 2-1. This schedule is based on a first stage in-service date of late 1993 and the routes recommended in this report.

The first stage of project planning is presently underway. This includes system planning, preliminary engineering and the preliminary environmental assessment and route location studies. The environmental and route location studies are documented for use in the public consultation stage which is scheduled for completion during 1984. B.C. Utilities Commission approval of the project is required by early 1986 in order to permit engineering surveys to commence in the same year. Project activities during the period of engineering surveys include an access assessment so that an access plan can be formulated prior to construction.

Construction would commence in 1987 and continue until completion of the first lines from the Iskut Canyon and More Creek generating sites to Telkwa and Skeena Substations in 1993. The two lines from the Stikine Canyon generating site and the second line to Telkwa Substation would be built concurrently until completion in 1995. The two lines between the Tanzilla and Stikine Canyon generating sites would be completed in 1997. The first phase of construction would be right-of-way logging followed by clearing in 1988. Installation of tower foundations would commence in 1990 followed by structure erection in 1991. Conductor stringing would follow in 1992.

It must be recognized that this is a preliminary schedule only. It may be modified as required for project implementation.

2.2 SYSTEM DISCUSSION

Preliminary studies by B.C. Hydro's System Engineering Division indicate that three high voltage (500 kV) transmission lines would be the most economic and electrically stable method to transmit electric power from the Stikine-Iskut generation sites to the existing provincial grid. The following system alternatives were defined and addressed in these studies:

1. one 500 kV transmission line to Skeena Substation and two 500 kV transmission lines to Telkwa Substation, or

2. one 500 kV transmission line to Skeena Substation and two 500-1000 kV transmission lines to the proposed Cluculz Station, or

3. three 500 kV transmission lines to Telkwa Substation, and one 500 kV transmission line between Telkwa and Skeena substations, or

4. three 500 kV transmission lines to Cluculz Station and one 500 kV transmission line between Telkwa and Skeena substations.

The nature of the project also made it necessary to integrate the four proposed generating sites with each other and the existing transmission system.

After examining the study area it was found that numerous route alternatives could be combined to meet either system objective. In order to evaluate the various route alternatives it was necessary to establish the methods by which the system objectives could be met. It was determined that six basic methods or schemes would satisfy the system objectives with various route alternatives within each scheme. These schemes are schematically outlined in Fig. 2.2 (Sheets 1-6) and described by the following.

2.3 SCHEME DESCRIPTIONS

Scheme I

Scheme I would have two 500 kV transmission lines from both the Stikine Canyon and Tanzilla generation sites coming together at a proposed Stikine Collector just south of the Stikine Canyon site. Two 500 kV transmission lines from the Stikine Collector; plus two 500 kV and one 230 kV transmission line from Iskut Canyon and More Creek generation sites respectively, then join together at a proposed collector station near Bob Quinn Lake. Three 500 kV transmission lines then head south from the Bob Quinn Collector with two of the 500 kV transmission lines continuing to Telkwa Substation and one heading to Skeena Substation.

Scheme II

Scheme II would have two 500 kV transmission lines from both the Stikine Canyon and Tanzilla generation sites coming together at a proposed Stikine Collector just south of the Stikine Canyon site. Two 500 kV transmission lines from the Stikine Collector plus one 500 kV transmission line from the Iskut Canyon generation site would then join together at a possible Muckaboo Collector near the confluence of Muckaboo Creek and the Nass River. Two 500 kV transmission lines would then continue to Telkwa Substation from the Muckaboo Collector. A 230 kV transmission line from the More Creek generation site would terminate at the Iskut Canyon generation site. A single 500 kV transmission line would proceed from Iskut Canyon to Skeena Substation.

Scheme III

Scheme III would be similar to Scheme I with two 500 kV transmission lines from the Stikine Collector, two 500 kV transmission lines from Iskut Canyon and one 230 kV transmission line from More Creek all coming together at the Bob Quinn Collector. Three 500 kV transmission lines

would then head south to Telkwa Substation. One 500 kV transmission line would then continue to Skeena Substation from Telkwa Substation in addition to the existing 500 kV transmission line.

Scheme IV

Scheme IV would be similar to Scheme II with two 500 kV transmission lines from the Stikine Collector, and one 500 kV transmission line from Iskut Canyon generating site coming together at the possible Muckaboo Collector. Two 500 kV transmission lines would then head south from the collector and meet one 500 kV transmission line from Iskut Canyon such that three 500 kV transmission lines continue to Telkwa Substation. One 230 kV transmission line from the More Creek generating site would terminate at the Iskut Canyon generating site. One 500 kV transmission line would then continue to Skeena Substation from Telkwa Substation in addition to the existing 500 kV transmission line.

Scheme V

Scheme V would have two 500 kV transmission lines from both the Stikine Canyon and Tanzilla generating sites coming together at a proposed Stikine Collector just south of the Stikine Canyon site. Two 500 to 1000 kV transmission lines would then proceed to an intermediate station approximately halfway between the Stikine Collector and Cluculz Station. They then continue to the propcsed Cluculz Station near Prince George. One 230 kV transmission line from the More Creek generating site would terminate at the Iskut Canyon generating site. Two 500 kV transmission lines would then leave the Iskut Canyon generating site with one heading north to the Stikine Collector and the other heading south to Skeena Substation.

Scheme VI

Scheme VI would have two 500 kV transmission lines from each of the three generating stations; Tanzilla, Stikine Canyon and Iskut Canyon coming together at a proposed Stikine Collector just south of the Stikine Canyon site. Three 500 kV or two 1000 kV transmission lines would then proceed to an intermediate station approximately halfway between the Stikine Collector and Cluculz Station. They then continue to the proposed Cluculz Station near Prince George. One 230 kV transmission line from the More Creek generating site would terminate at the Iskut Canyon generating site. One 500 kV transmission line would proceed to Skeena Substation from Telkwa Substation in addition to the existing 500 kV transmission line.

In order to meet projected load and provide a dependable supply of power in the Northwest a second transmission line is required between Williston Substation, near Prince George, and Telkwa Substation. This line will proceed independently of the Northern Hydro Developments and is scheduled to be in service by approximately 1989. Therefore, a Williston-Telkwa transmission line is not considered in the comparison of route alternatives for Schemes V and VI in the Stikine-Iskut High Voltage Transmission System. Further information on power requirements in this area may be found in Electricity in Northwestern British Columbia, May 1981 (available through B.C. Hydro Public Affairs).

In Schemes I, II, III and IV the preferred transmission voltage is 500 kV using single circuit structures, with the exception of double circuit structures along segment 5-13 in Schemes I and III. In Schemes V and VI a voltage higher than 500 kV may be required for the section between the proposed Stikine Collector and the proposed Cluculz Station. A voltage range between 500 and 1000 kV is being considered using single circuit structures.

2.4 DESIGN INFORMATION

Transmission structures and conductors for these lines have not yet been designed by B.C. Hydro and outline drawings are therefore not available. However, Fig. 2-3 Sheet 1, shows the legal right-of-way requirements for one, two or three 500 kV single circuit transmission line(s) based on present conventional guyed tower design. The right-of-way requirements for one single circuit 500 kV plus one double circuit 500 kV transmission line is also shown. Fig. 2-3, Sheet 2 shows the proposed right-of-way requirements for an alternative design using inverted delta phase configuration on cross-rope suspension structures. Fig. 2-3, Sheet 3 shows the proposed right-of-way requirements for one or two 1000 kV single circuit transmission line(s) based on present conventional guyed tower design. Should another voltage within the 500 kV to 1000 kV range be selected then the right-of-way requirements would change proportionately. The typical circuit to circuit separations shown in Fig. 2-3 could vary along the route depending upon design details and alignments. It was assumed in this study that when three lines continue to the same destination they would remain on common right-of-way wherever practicable.

Regardless of voltage selected, the design will likely result in an average span length of approximately 400 m i.e. 2.5 structures per kilometre. Individual span lengths would vary depending on the topography along the transmission centreline.

Appendix A (Survey and Construction Procedures) describes the procedures for survey, access development and construction that are common to 500 kV transmission line projects.

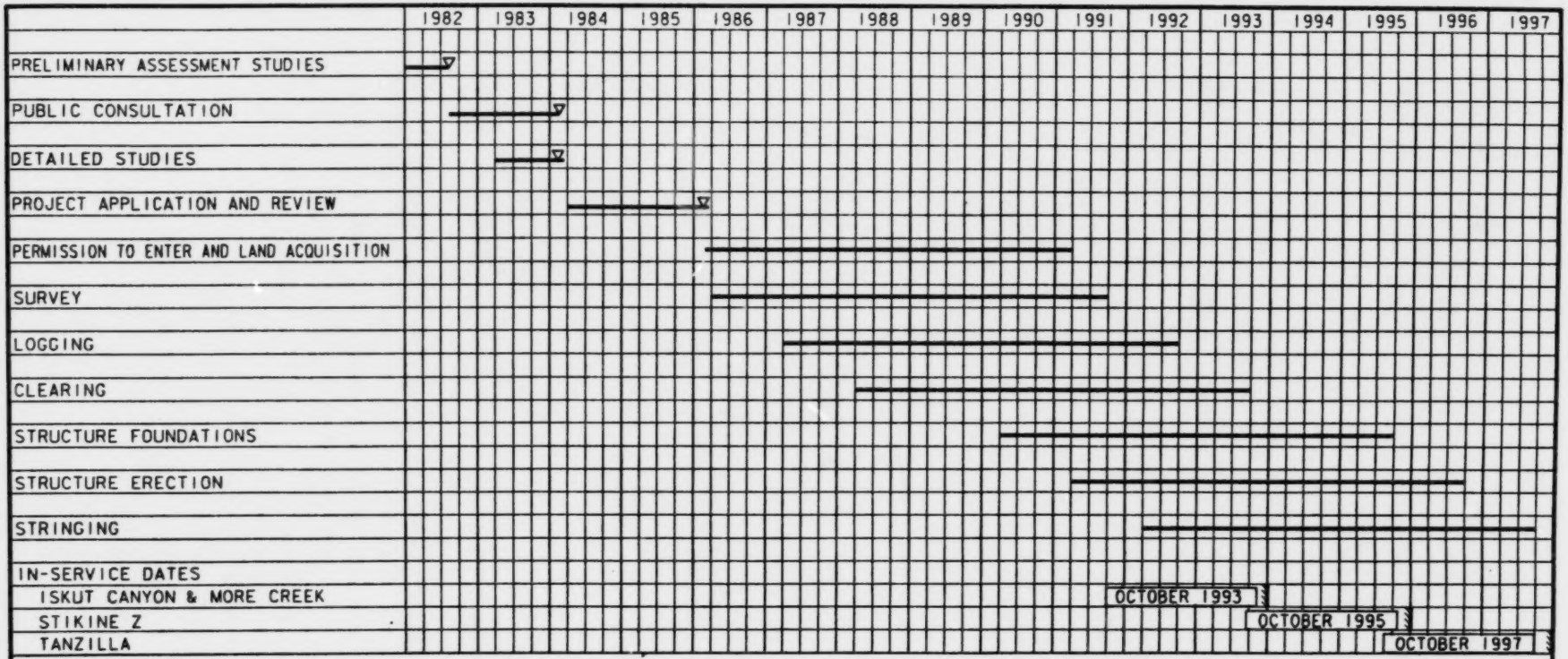
2.5 STATIONS

The general location for the various stations proposed in each scheme of this project is shown in Fig. 2-2 (Sheets 1 to 6). There are four types of stations that may be used in this project. They are listed here and described in the glossary:

1. collector station
2. capacitor station
3. switching station
4. substation

The stations may be combined to perform various functions. Once the general area in which a station is required has been determined, a more detailed investigation is made to identify the specific site. The selection of a station site involves the consideration of many engineering criteria, the most important of which are:

1. station size
2. topography
3. security
4. suitability for related transmission lines
5. accessibility

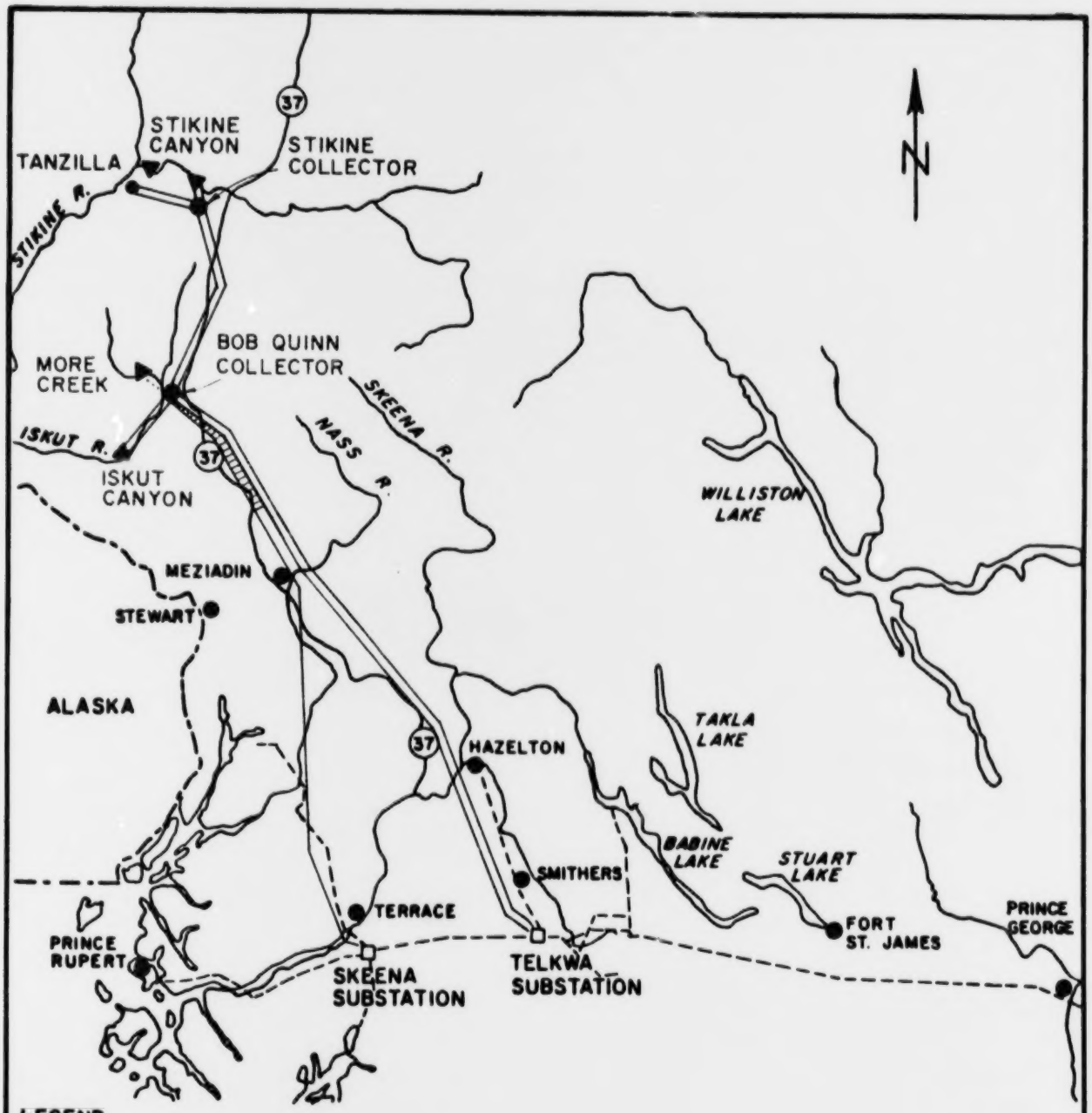


NOTE:
SOLID BAR INDICATES TIME FRAME WITHIN WHICH THE ACTIVITY MUST BE ACCOMPLISHED.
THE ACTUAL PERIOD OF EFFORT MAY BE LESS.

BC Hydro

STIKINE-ISKUT
HIGH VOLTAGE TRANSMISSION
SYSTEM
PRELIMINARY SCHEDULE

DATE	FIGURE 2.1
DRAWN	DWG. NO



LEGEND

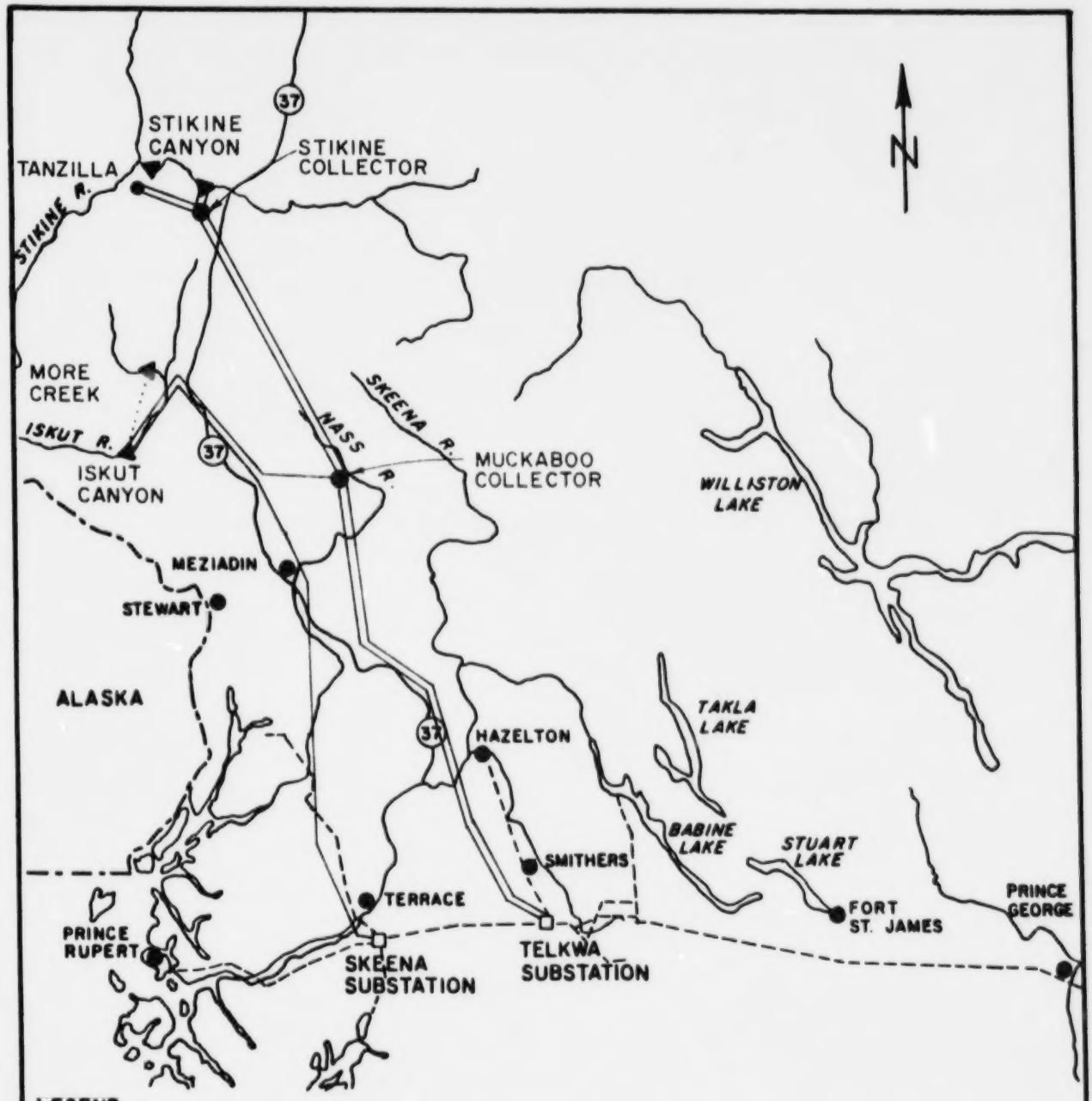
- PROPOSED 500kV SINGLE CIRCUIT TRANSMISSION LINE
- PROPOSED 230kV SINGLE CIRCUIT TRANSMISSION LINE
- EXISTING TRANSMISSION LINES (138kV AND HIGHER)
- PROPOSED 500 kV DOUBLE CIRCUIT TRANSMISSION LINE
- PROPOSED DAM
- PROPOSED COLLECTOR

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM

SCHEME I SCHEMATIC

DATE	FIGURE 2-2
DWN	Dwg No SHEET 1 OF 6

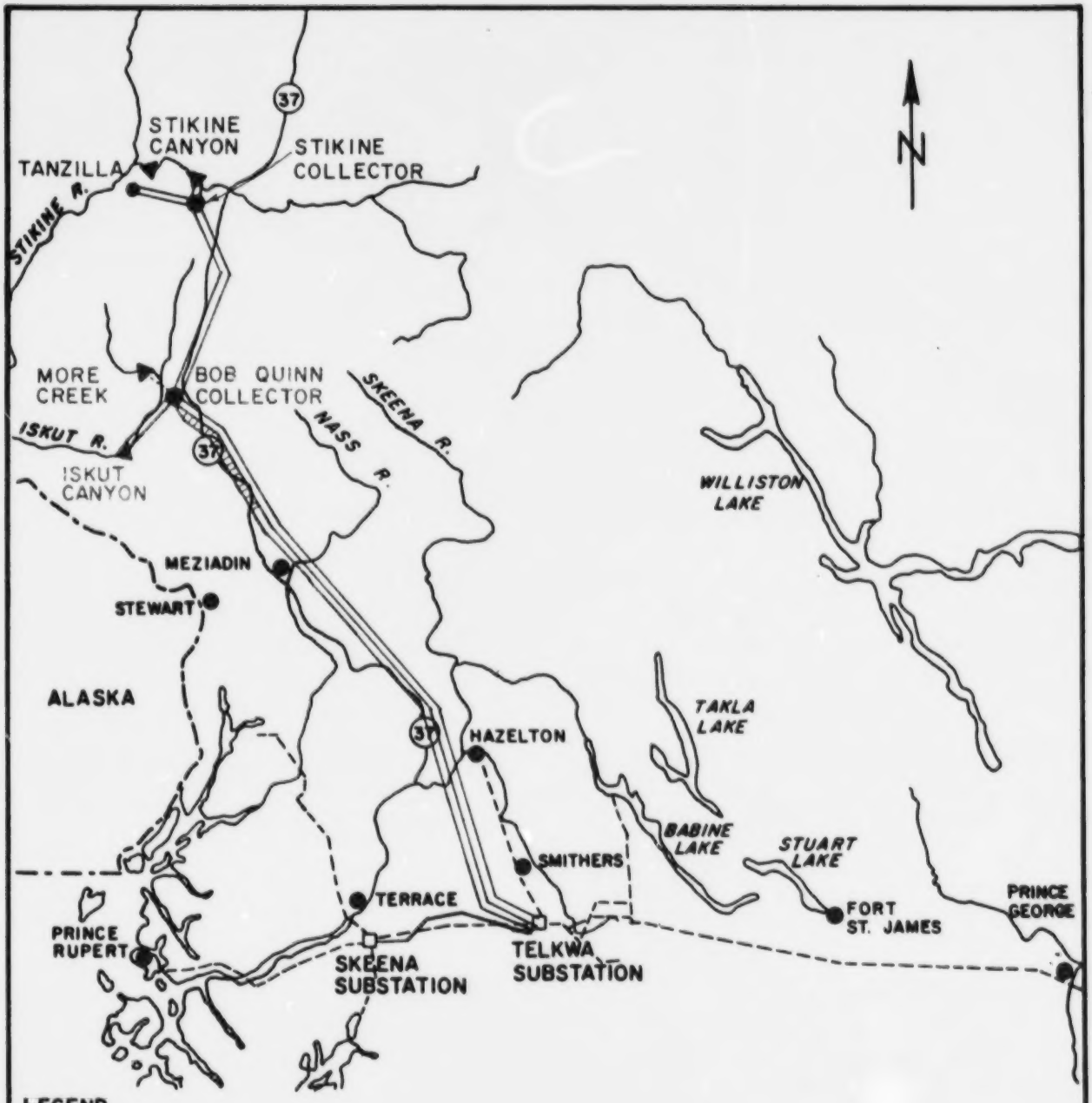


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM

SCHEME II SCHEMATIC

DATE	FIGURE 2-2
DWN	Dwg No SHEET 2 OF 6



LEGEND

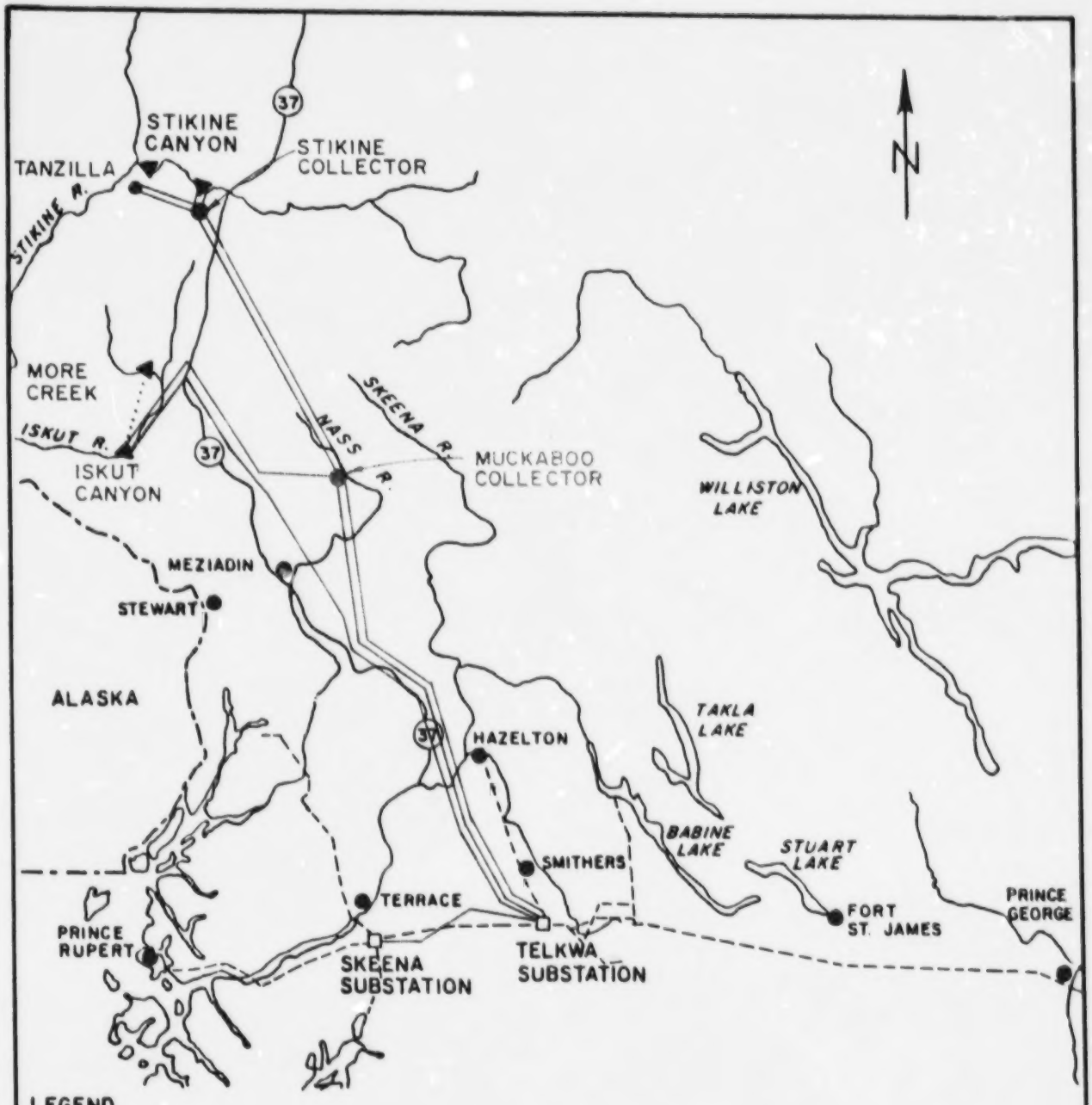
- PROPOSED 500kV SINGLE CIRCUIT TRANSMISSION LINE
- PROPOSED 230kV SINGLE CIRCUIT TRANSMISSION LINE
- EXISTING TRANSMISSION LINES (138kV AND HIGHER)
- PROPOSED 500 kV DOUBLE CIRCUIT TRANSMISSION LINE
- PROPOSED DAM
- PROPOSED COLLECTOR

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM

SCHEME III SCHEMATIC

DATE	FIGURE 2-2
DWN	DWG. No SHEET 3 OF 6



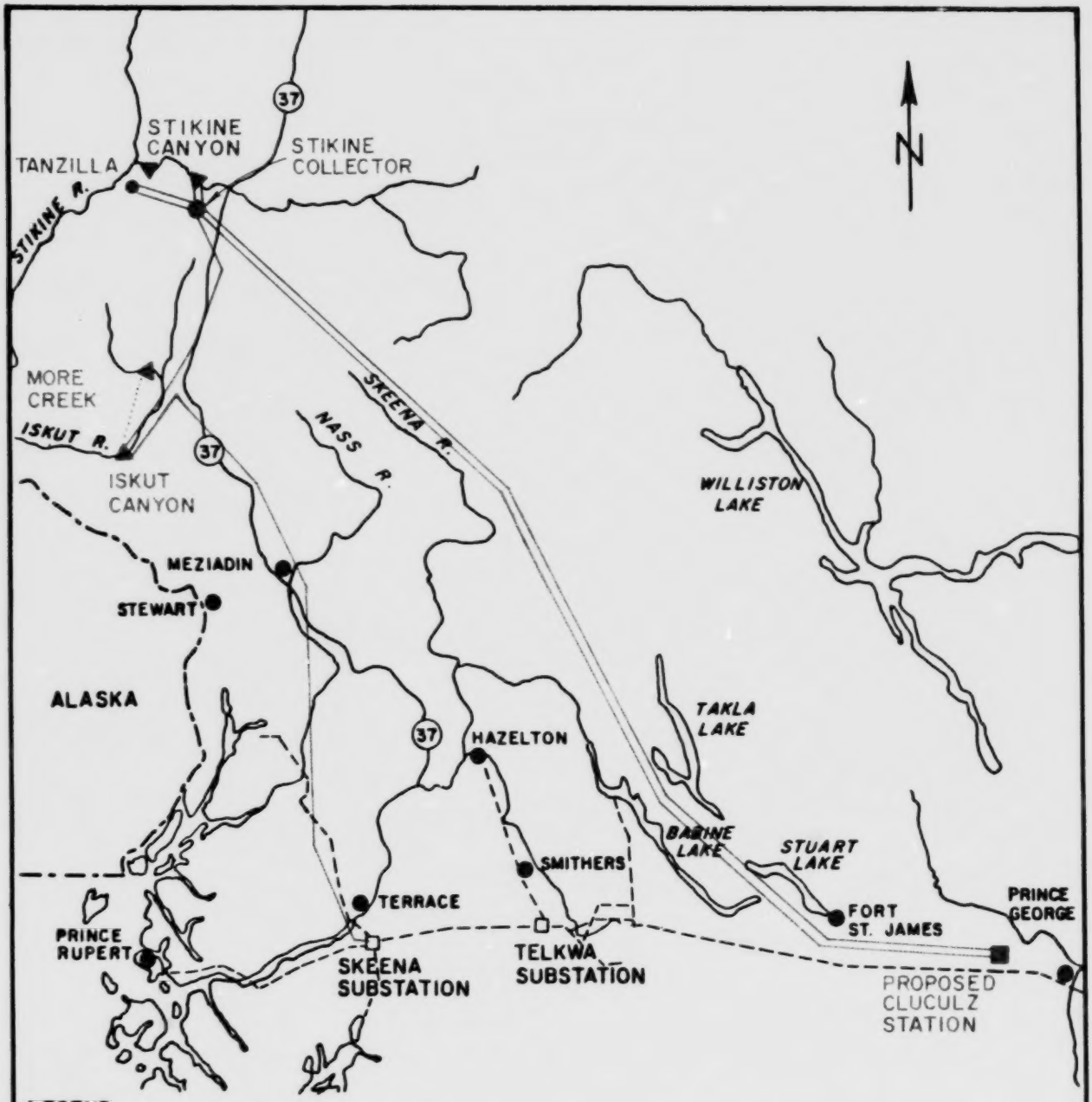
LEGEND

- PROPOSED 500kV SINGLE CIRCUIT TRANSMISSION LINE
- PROPOSED 230kV SINGLE CIRCUIT TRANSMISSION LINE
- EXISTING TRANSMISSION LINES (138kV AND HIGHER)
- ▲ PROPOSED DAM
- ● PROPOSED COLLECTOR

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM SCHEME IV SCHEMATIC

DATE	FIGURE 2-2
DWN	DWG No SHEET 4 OF 6



LEGEND

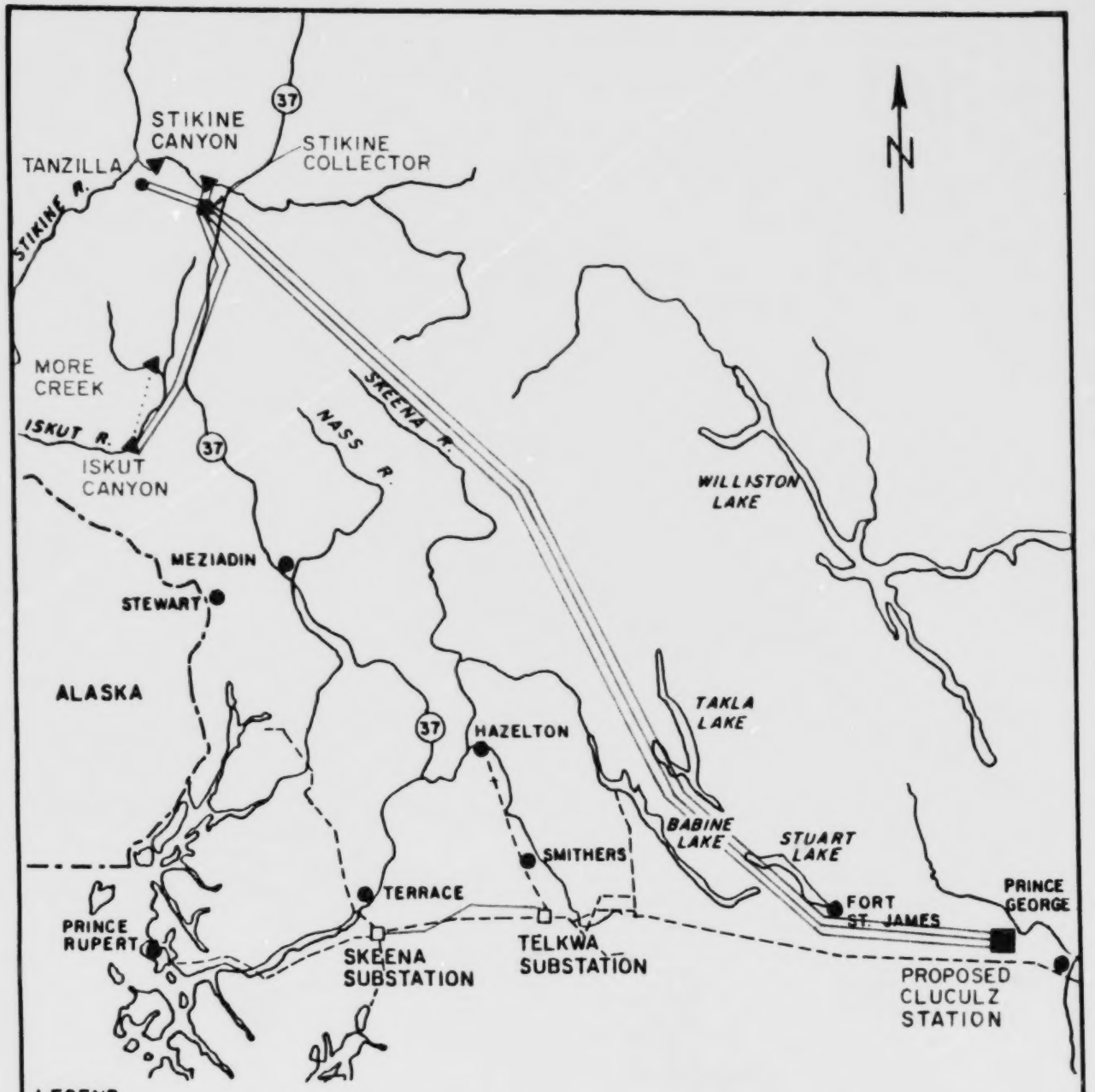
- PROPOSED 500kV SINGLE CIRCUIT TRANSMISSION LINE
- PROPOSED 230kV SINGLE CIRCUIT TRANSMISSION LINE
- EXISTING TRANSMISSION LINES (138kV AND HIGHER)
- PROPOSED DAM
- PROPOSED COLLECTOR

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM

SCHEME V SCHEMATIC

DATE	FIGURE 2-2
DWN	DWG No SHEET 5 OF 6



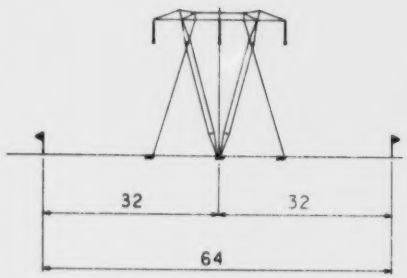
LEGEND

- PROPOSED 500kV SINGLE CIRCUIT TRANSMISSION LINE
- PROPOSED 230kV SINGLE CIRCUIT TRANSMISSION LINE
- EXISTING TRANSMISSION LINES (138kV AND HIGHER)
- PROPOSED DAM
- PROPOSED COLLECTOR
- PROPOSED STATION

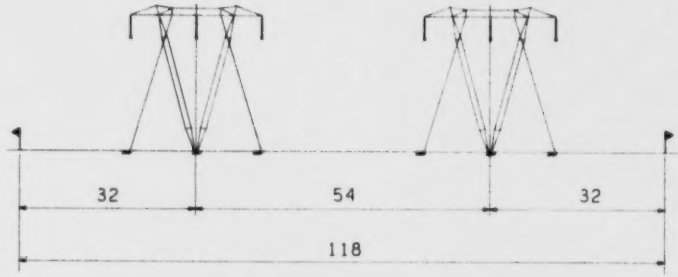
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE – ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM SCHEME VI SCHEMATIC

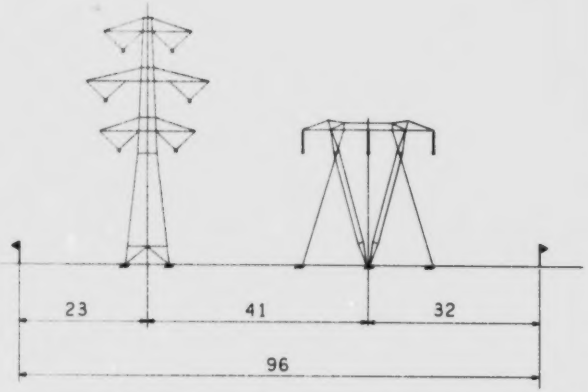
DATE	FIGURE 2-2
DWN	DWG No SHEET 6 OF 6



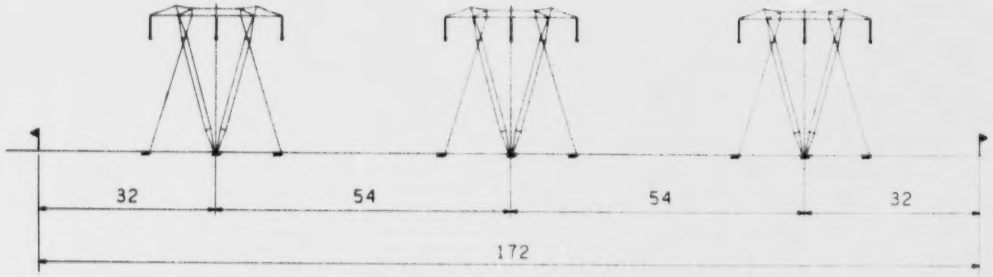
R/W FOR ONE SINGLE CIRCUIT
500 kV TRANSMISSION LINE



R/W FOR TWO SINGLE CIRCUIT
500 kV TRANSMISSION LINES



R/W FOR ONE DOUBLE CIRCUIT 500 kV TRANSMISSION LINE
AND ONE SINGLE CIRCUIT 500 kV TRANSMISSION LINE



R/W FOR THREE SINGLE CIRCUIT
500 kV TRANSMISSION LINES

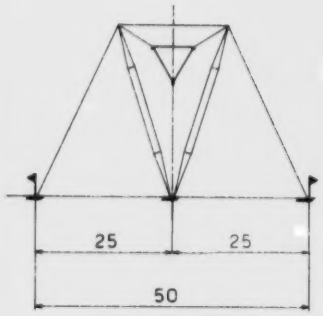
NOTES:

1. DIMENSIONS ARE BASED ON PRELIMINARY STRUCTURE DRAWINGS.
2. DIMENSIONS ARE IN METRES.

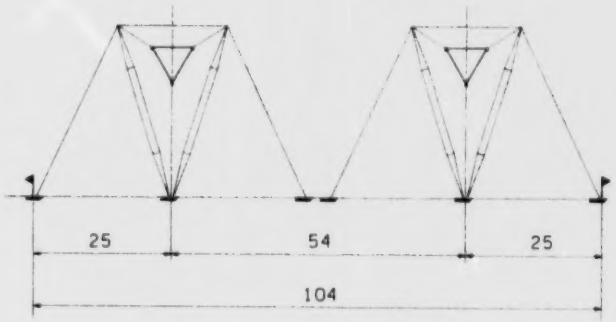
B.C. Hydro

STIKINE-ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
TYPICAL RIGHT-OF-WAY REQUIREMENTS
STANDARD SINGLE CIRCUIT PHASE CONFIGURATION

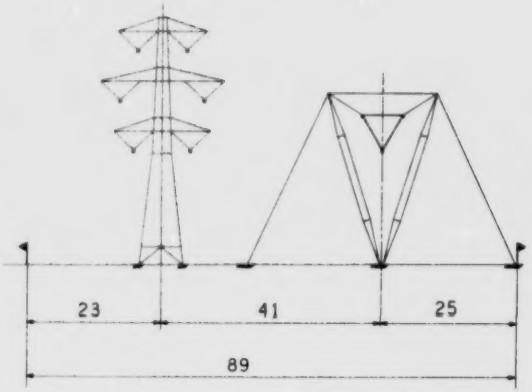
DATE	FIGURE 2-3 Sh. 1 of 3
DWN	DWG. NO.



R/W FOR ONE SINGLE CIRCUIT
500 kV TRANSMISSION LINE



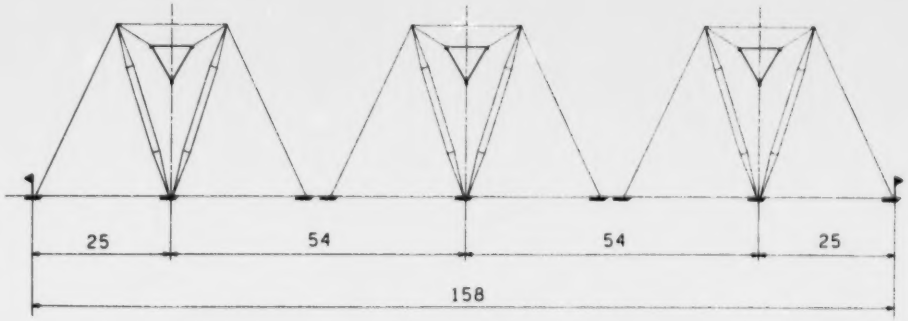
R/W FOR TWO SINGLE CIRCUIT
500 kV TRANSMISSION LINES



R/W FOR ONE DOUBLE CIRCUIT 500 kV TRANSMISSION LINE
AND ONE SINGLE CIRCUIT 500 kV TRANSMISSION LINE

NOTES:

1. DIMENSIONS ARE BASED ON PRELIMINARY STRUCTURE DRAWINGS.
2. DIMENSIONS ARE IN METRES.



R/W FOR THREE SINGLE CIRCUIT
500 kV TRANSMISSION LINES

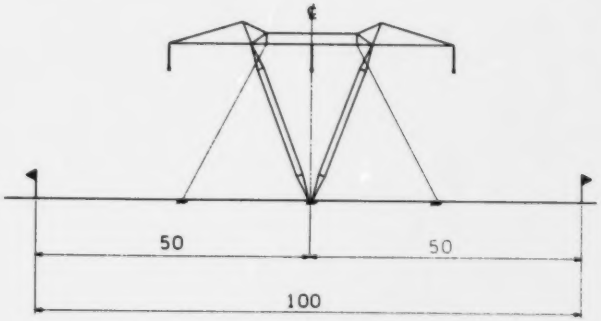
BC Hydro

STIKINE-ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM

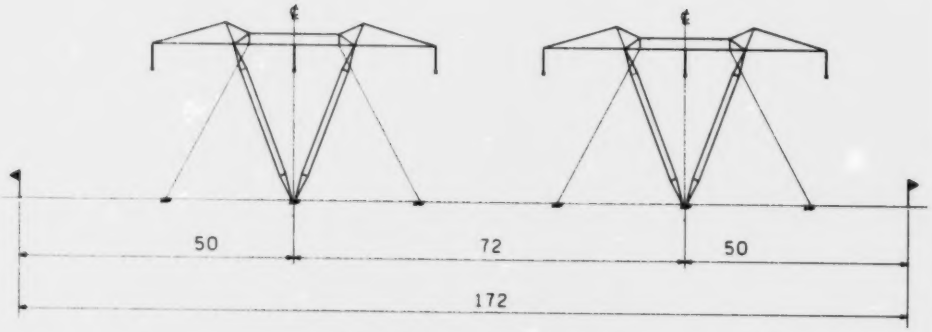
TYPICAL RIGHT-OF-WAY REQUIREMENTS

INVERTED DELTA SINGLE CIRCUIT PHASE CONFIGURATION

DATE	FIGURE 2-3 Sh. 2 of 3
DWN	DWG. No.



R/W FOR ONE SINGLE CIRCUIT
1000 kV TRANSMISSION LINE



R/W FOR TWO SINGLE CIRCUIT
1000 kV TRANSMISSION LINES

NOTES

1. DIMENSIONS ARE BASED ON PRELIMINARY STRUCTURE DRAWINGS.
2. DIMENSIONS ARE IN METRES.

B.C. Hydro	
STIKINE-ISKUT HIGH VOLTAGE TRANSMISSION SYSTEM TYPICAL RIGHT-OF-WAY REQUIREMENTS STANDARD SINGLE CIRCUIT PHASE CONFIGURATION	
DATE	FIGURE 2-3 Sh. 3 of 3
DWN	DWG. No.

SECTION 3.0 - ROUTE DESCRIPTIONS

3.1 INTRODUCTION

Four sources of hydroelectric generation have been identified, two on the Stikine River at Tanzilla and Stikine Canyon, one at More Creek and one on the Iskut River at Iskut Canyon. Electricity generated at these sites would be transmitted to the existing B.C. Hydro electric system within the study area. The study area is characterized by numerous valleys and passes that were examined and divided into acceptable and unacceptable routes for transmission lines. These routes are shown on Plate 3-1, Sheets 1 and 2, Plan of Route Alternatives. The few unacceptable routes that were studied are predominantly in the Klappan Range of the Skeena Mountains. Plate 3-1 represents over 3900 km of acceptable route segments which are described in this section. The descriptions are general, emphasizing only the significant features of the route segments. Possible station locations are also discussed briefly. It should be noted that a precise location for the proposed lines will not be determined until the next more detailed stage of study. In order to define the acceptable route segments, numbers were assigned to points where there is a change in terrain or an intersection between two or more segments. The segments are thereby described by the numbers assigned to the points at either end.

3.2 UNACCEPTABLE ROUTES

(a) Burrage and Alger Creeks (east from point 4)

The entrance to Burrage Creek is quite suitable to transmission line construction but the valley sides soon become steep, with numerous avalanche paths, as the creek rises rapidly to a 1200 m

elevation. At this point the route passes into the headwaters of Alger Creek. The sides of Alger Creek valley also rise sharply to the Mt. Alger icefield on the east and another icefield on the west. These icefields can accumulate large amounts of snow which cause avalanches in winter and flash floods in spring. Transmission through this area would be very insecure and therefore unacceptable.

(b) Owl Creek (east from point 14)

Owl Creek is a short, fast rising stream flowing through a narrow valley with steep side slopes that are prone to avalanches. The route passes over the 1400 m elevation where transmission lines could also experience high winds and icing conditions.

(c) Teigen Creek (east of point 7)

A route through this area would pass over the 1400 m elevation near existing glaciers. The area is void of trees and transmission lines through here could be exposed to high winds and icing conditions. Construction costs would be very high and the lines very insecure. There are also steep slopes adjacent to Teigen Creek with numerous avalanche paths.

(d) Little Klappan River (southeast of point 34)

The Little Klappan River valley is narrow with steep, unstable side slopes. It is already occupied by the British Columbia Railway (BCR) grade and Spatzizi Park on the north bank. Transmission lines on the west bank could not be located to provide adequate security from slope failures and avalanches.

3.3 STATION DESCRIPTIONS (Refer to Plate 3-1, Sheets 1 and 2)

(a) Stikine Collector

This collector station would be located on a level bench near the Stikine Canyon generating site and would be common to all schemes. It would combine the two transmission lines from the Tanzilla generating site with the two transmission lines from the Stikine Canyon generating site. Transmission lines would then transmit the power south from the collector station. An estimate for the size of the Stikine Collector is between 6 to 8 hectares.

(b) Bob Quinn Collector

This collector station would be located on a fairly level area near Bob Quinn Lake and is common to Schemes I and III. It combines transmission line(s) from the Stikine Collector, Iskut Canyon generating site and More Creek generating site. Transmission line(s) then leave Bob Quinn Collector and proceed to Skeena and/or Telkwa substations depending on the scheme. An estimate for the size of the Bob Quinn Collector is 10 to 12 hectares.

(c) Muckaboo Collector

This collector station would be located near the confluence of Muckaboo Creek and the Nass River. This station is required for Schemes II and IV. At the present time there is no access into the area where the station would be located. The station combines two transmission lines from the Stikine Collector with a transmission line from the Iskut Canyon generating site. Two transmission lines proceed from this collector to Telkwa Substation. This station location was introduced when the preliminary location study was nearing completion as an alternative to Bob Quinn Collector. It

would otherwise not have been considered due to its remoteness. An estimate of the size of the Muckaboo Collector is 14 to 16 hectares.

(d) Skeena Substation

The Skeena Substation is located about 10 km south of Terrace. It presently handles 60, 138, 287 and 500 kV transmission lines but would require expansion to accommodate the additional transmission system proposed in all schemes.

(e) Telkwa Substation

The Telkwa Substation is located about 40 km southeast of Smithers. It presently handles 138 and 500 kV transmission lines but would require expansion to accommodate the additional transmission system proposed in all schemes.

(f) Cluculz Station

This station is proposed only in Schemes V and VI in the general area of Cluculz Lake and north of Highway 16 about 50 km west of Prince George. This site was chosen for the following reasons:

1. Junction of Liard and Stikine-Iskut transmission systems.

2. Integration of high voltage systems with existing and future transmission lines in this area.

3. Accessibility from Highway 16.

An estimate for the size of the Cluculz Station is up to 50 hectares.

(g) Intermediate Station

An intermediate station would be required in Schemes V and VI only as a switching station to provide operating flexibility. It would be located approximately halfway between the Stikine Collector and the proposed Cluculz Station.

(h) Capacitor Stations

Several capacitor stations would be required on this project but the number and location would depend on the scheme chosen. Station facilities, either at mid-point or at line terminal locations would be required for transmission lines between:

1. Iskut Canyon and Skeena Substation in Schemes II and V.

2. Iskut Canyon and Telkwa Substation in Scheme IV.

3. Bob Quinn Collector and Telkwa Substation in Schemes I and III.

4. Bob Quinn Collector and Skeena Substation in Scheme I.

5. Muckaboo Collector and Telkwa Substation in Schemes II and IV.

6. Stikine Collector and intermediate station; and between intermediate station and Cluculz Station in Schemes V and VI. An estimate for the size of capacitor stations is 2 ha.

View of the Stikine River Canyon looking west towards proposed Tanzilla damsite. (Segment 1-2)

View looking north from Iskut towards the proposed Stikine Canyon damsite. The road through the middle is Highway 37. (Segment 2-3)

(ii) Stikine Collector - Bob Quinn Collector

There are basically two routes between the Stikine and Bob Quinn collectors.

One route, segment 2-3-4, follows the Iskut River valley, generally staying to the east of the Stewart-Cassiar Highway. In segment 2-3, to the northwest of the highway, the terrain is undulating and scattered with swamps and light tree cover. The portion of segment 3-4 in the region of Iskut village and Eddontenajon Lake becomes narrow, is heavily forested and flanked to the east by Mt. Ehahcezetle. The mountain influences the route with regions of considerable side slope and avalanche paths. Proceeding southerly, segment 4-5, the valley broadens and the terrain changes to rolling with flat regions. Tree cover is reduced and gives way to vast burn areas. Highway 37 (Stewart-Cassiar) provides access into most areas of this region.

The second route, segment 2-4, follows Kakiddi Creek between the Stikine Collector and the lower end of Kinaskan Lake. This is a low lying region to the east of Mt. Edziza Park. Forest cover varies from heavy to bare, burned over areas. The terrain is variable from flat with swampy sections to rolling. There is no ground access to this region at present. This route has no advantages other than avoiding the narrower section of the first route near the base of Mt. Ehahcezetle.

(iii) More Creek - Bob Quinn Collector

The route between the More Creek generating site and Bob Quinn Collector traverses the Iskut River valley. Access to this region would be provided by the permanent road to the More Creek generating site.

View of proposed Bob Quinn Collector site looking north up Iskut River Valley. Bob Quinn Lake is at upper left. (Segment 4-5)

View of Highway 37 looking north through the Ningunsaw Creek Valley. (Segment 5-14)

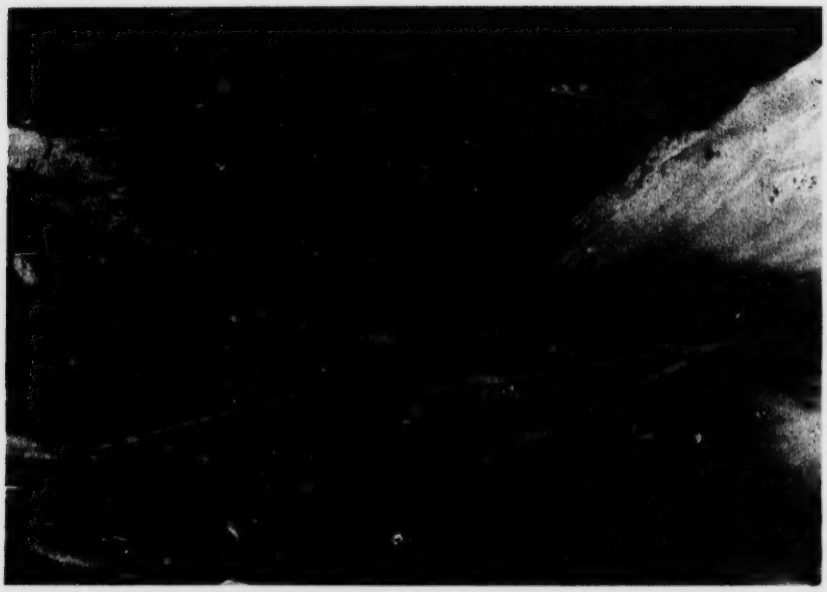
(iv) Bob Quinn Collector - Bell-Irving/Taft Creek Confluence

The triangular region bounded by Bob Quinn Collector, Iskut Canyon dam and the confluence of the Bell-Irving River and Taft Creek presents the most technical problems of the entire study area. The heavy annual snowfall received by the region accumulates on the steep mountain slopes and results in numerous snow avalanches. Some of these reach gigantic proportions. Transmission lines in exposed locations in this area would also be subject to high ice and wind loadings.

Route segments 5-14-13 interact with Highway 37 along the Ningunsaw River, Beaverpond and Snowbank creeks and the Bell-Irving River valley. Segment 5-14 contains a number of major avalanche zones which would present a security risk to transmission lines. An avalanche overview study [P. Schaerer, Avalanche Hazard to Transmission Lines at Ningunsaw Pass, Treaty Creek, Iskut, National Research Council of Canada, April 1981] of segment 5-14 concludes that up to two individual transmission lines could be placed along this route with acceptable security. Therefore, following this route would require double circuit construction for one of the two transmission lines through segment 5-14. The precise location of transmission lines along this route would be governed by the selection of secure tower sites on an individual basis.

(v) Bob Quinn Collector - Iskut Canyon

Between Bob Quinn and Iskut Canyon the route (segments 5-7-8-9) follows the Iskut River valley and the reservoir that would be created by the dam. The route would generally follow the access to the dam which is proposed along the eastern edge of the valley (5-7). The east side along the southern portion of the valley (8-9) becomes steep and avalanche swept. To



View of the Unuk River pass looking west towards the proposed Iskut Canyon damsite. (Segment 10-11)

View of Highway 37 adjacent to the Bell-Irving River looking north. (Segment 15-13)

avoid this region which presents a security risk due to snow avalanches it might be necessary to cross to the west side of the reservoir (7-8) to take advantage of rock outcrops for tower placement. Near the dam the route would again swing to the east side of the reservoir below the damsite to access the powerhouse.

(vi) Iskut Canyon - Bell-Irving/Taft Creek Confluence

This route, consisting of segments 9-10-11-12-13, proceeds easterly to the upper region of the Unuk River, Teigen and Treaty creeks. The placement of the Iskut Canyon powerhouse would require traversing an extremely unstable, avalanche prone slope to enter this segment. A number of critical avalanche zones exist throughout this segment and would present a security risk to a transmission line. Snow depths along this route segment are high and upper elevations, which are exposed, may be subject to high winds as well. No access exists along this segment which would make transmission line construction and line maintenance difficult in the case of an outage.

(vii) Bell-Irving/Taft Creek Confluence - Telkwa Substation

Between the Bell-Irving/Taft Creek confluence (point 13) and the Telkwa Substation two alternate routes exist. The northern leg of both routes, consisting of segments 13-15-21, is common to a point near Swan Lake where the two route options commence, one to the east and one to the west of the Kispiox Range. The easterly leg comprised of segments 21-30-41-32 generally remains east of the Kispiox and Bulkley rivers and has good existing access. Along the southern section the route lies along the west base of the Babine Range.

View of logging through Cranberry River Valley looking south towards Kitwanga Lake with Highway 37 in centre of photo. (Segment 21-22)

View of logging in the Cedar River Valley looking north. Improved logging road and adjacent 138 kV transmission line are shown on left of photo crossing the Kitsumkalum River. (Segment 17-18)

The westerly leg, comprised of segments 21-22-26-29-31-32, would remain east of the Cranberry and Kitwanga rivers and cross the Skeena River. It would then follow the Kitseguecla River and the valley west of Hudson Bay Mountain to Telkwa Substation. All the valleys along this section are wide with gently rolling terrain and some lakes. There is extensive logging in some areas and good access.

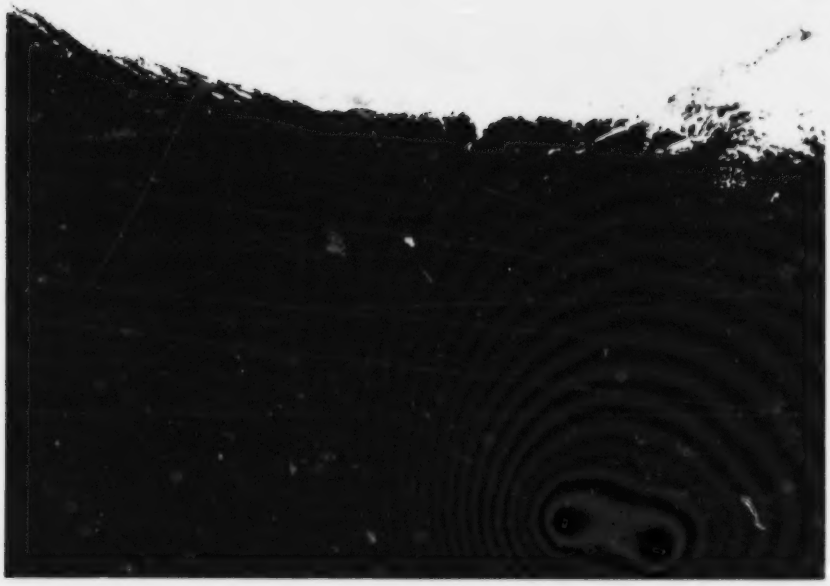
(viii) Iskut Canyon - Skeena Substation

Several alternative routes are possible between Iskut Canyon and the Skeena Substation. Through the northern third of the region to point 15, the segments are common with those described above leading to the Telkwa Substation. Throughout the lower two thirds of the region the route to Skeena could branch off from the western leg of a route to Telkwa at points 15, 22 or 26.

The most westerly route alternative to Skeena (segments 15-16-17-18) leaves the Kitwanga River route to Telkwa near the Nass River, follows portions of the White and Kinskuch rivers, proceeds across the Nass River valley and then along the Tseax, Cedar and Kitsumkalum river valleys to the Skeena Substation. The gently rolling terrain north of the Nass River crossing has no existing access. South of the Nass River valley considerable logging has taken place which provides good access throughout the area. One existing lattice aluminum 138 kV transmission line is located along the route south of the Nass River.

A second alternative route (segments 15-19-20-17-18) leaves the Telkwa route at the same location near the Nass River but remains more to the east near the existing road access. It then follows the Kiteen and Cedar River valleys and rejoins

View north down the Kiteen River with the Nass Valley in the left background. (Segment 19-20)



View of Williams Creek looking east toward Trapline Creek confluence at upper left of photo. (Segment 28-25)

the first alternative in the region of Kitsumkalum Lake. This segment by-passes that part of the first alternative between Lava Lake and the Nass valley. The valley of the Kiteen River and into the headwaters of the Cedar River has steep side-slopes and signs of previous snow avalanches. There is no existing access in the Kiteen valley and only limited access in the Cedar River valley.

A third alternative route (15-19-16-17-18) in this area follows the second alternative along Highway 37 but turns southeast at point 19. It then follows the Nass and Tseax rivers instead of the Kiteen and Cedar rivers to point 17. This route then continues along the Kitsumkalum River to Skeena Substation. This route has good existing access and easy terrain.

Two other alternatives are possible to the east of the routes just discussed. One route follows the Skeena River valley. This route would be located generally along the southeast side of the river above Highway 16 following segments 22-23-24-25-18. Steep terrain exists on the southern part of this route between points 23 and 24. The route narrows near Terrace and also contains the existing transmission line circuit 5L63.

The other route follows the Zymoetz River to a point west of Telkwa Pass where it intersects the existing 500 kV transmission line (circuit 5L63) from Telkwa Substation and then parallels the north side of this circuit to the Skeena Substation along segments 26-27-24-25-18. Route segment 26-27 along the upper Zymoetz River has no access, however, the terrain is quite acceptable to transmission line location. The narrow portion of the route near Terrace (24-25) could be avoided by a route to the south along Williams Creek following seg-

ments 27-28-25. Considerable access already exists along Williams Creek and is continuously being extended as logging progresses.

(b) Scheme II

A key difference between Schemes II and IV as compared to Schemes I and III is the location of a collector near the confluence of Muckaboo Creek and the Nass River instead of near Bob Quinn Lake.

The Muckaboo Collector introduces additional feasible routes between the proposed hydroelectric sites and Telkwa Substation. However, this proposed collector is 56 km from existing access and would introduce considerable maintenance and construction difficulties.

(i) Stikine Collector - Muckaboo Collector

There are two alternate routes from the proposed Stikine Collector to point 34 on the Klappan River. One route (2-34) follows the Stikine River while the other proceeds to Iskut village (2-3-34). The route along the Stikine River (2-34) traverses the rolling terrain south of the Stikine River along a region which would become part of the reservoir behind the Stikine Canyon dam. The terrain along this segment is unstable and could be aggravated by the reservoir. The other route (2-3-34) proceeds from the Stikine Collector towards Iskut village then easterly to the Klappan valley. Both routes then follow the Klappan and Nass rivers to the proposed Muckaboo Collector (34-35-36). The British Columbia Railway sub-grade follows the east bank of the Klappan River and continues up the Little Klappan River. However, there is no suitable transmission line route along the Little Klappan River due to the narrow valley and Spatzizi Park to the north.

View down the Klappan River Valley looking north.
(Segment 34-35)

View up Taft Creek looking east toward Muckaboo
Creek. (Segment 13-36)

Precise alignments along this route would be influenced by regions of swampy ground, unstable soil and snow avalanche paths. The only existing access along this route is the BCR grade in the lower Klappan valley which is located on the opposite side of the river from the proposed transmission route and is interrupted by missing bridges and culverts.

(ii) Iskut Canyon - Muckaboo Collector

Two possible route alternatives could tie Iskut Canyon and More Creek generating sites to the possible Muckaboo Collector. One route follows the Iskut River north and then turns south to follow Beaverpond and Snowbank creeks to the confluence of the Bell-Irving River and Taft Creek (point 13). The other route heads east along the Unuk River, Teigen and Treaty creeks (9-10-11-12-13) to meet the previous route at Taft Creek. These routes were described under Section 3.4(a), Scheme I, (iv), (v) and (vi).

The route to the Muckaboo site then proceeds east along Taft Creek. For the most part this route follows Taft Creek but also makes use of Taylor River and Muckaboo Creek. The valley bottoms which are narrow in places, are generally swampy and several confined avalanche paths exist along the sides. The pass from Taft Creek into the Taylor River valley is exposed due to an extensive forest fire and may be subject to icing conditions and high speed winds.

No access exists along this route, but it is understood that the B.C. Ministry of Forests is planning to construct an access road along Taft Creek from Highway 37 to the Nass River valley.

View looking south near the confluence of the Taylor and Nass Rivers. (Segment 36-38)

View looking west along the wilderness slopes surrounding Damdochax Creek. (Segment 37-39)

(iii) Muckaboo Collector - Telkwa Substation

There are five basic route options available between the proposed Muckaboo Collector and Telkwa Substation. Three options run southerly to intersect a route along the Kispiox or Kitwanga river valleys and the other two options approach from the east along McKendrick Creek.

The first southerly option (36-38-57-30-41-32) follows Kotsinta Creek, crosses the Nass River valley and then proceeds south and east following the west and south sides respectively of the Skeena Mountains to the Kispiox River valley. The route then follows the wide and accessible Kispiox and Bulkley river valleys to Telkwa Substation. In the northern section a minor deviation (36-37-38) which continues along the Nass valley before turning south would provide an alternate to the Kotsinta Creek section. The second southerly option (36-38-57-21-22-26-29-31-32) is similar to the previous option except the southern portion follows the Cranberry and Kitseguecla rivers to Telkwa Substation. The Cranberry and Kitseguecla rivers route was described under Section 3.4(a), Scheme I, (vii).

The third southerly option proceeds to the Kispiox valley (36-37-39-40) along the Nass River, turns up Damdochax Creek and follows along the Slamgeesh River. It then crosses the Skeena River valley near Babiche Hill and proceeds down the Sicintine River to a point where either a route along the Skeena River (40-41) or along Shedin Creek (40-56-41) could be followed to the Kispiox River. Valley bottoms along both these routes contain large swampy regions while the valley walls show signs of avalanches. The valleys are generally wide and thus provide ample space for transmission line

location. There is no existing access along these routes but there is access in the Kispiox and Bulkley river valleys.

The fourth option is an easterly route between Muckaboo and Telkwa (36-37-39-42-43-32), leaving the third option at Babiche Hill (point 39). It then proceeds up to the headwaters of the Sicintine River and down the Shelagyote River to the Babine River valley. Once in the valley (point 43) the route turns to the south, skirts the east side of the Babine Range and continues toward Telkwa Substation via McKendrick Creek. This route is generally easy with good access except for some steep slopes through the narrow McKendrick Creek valley.

The fifth option, the most easterly route between Muckaboo and Telkwa (36-37-39-45-46-43-32), leaves the third option at Babiche Hill (point 39). It heads east along the Skeena River and then southeast at point 45 to follow the Squingula and Nilkitkwa rivers to point 46. These river valleys are wide with easy to moderate terrain but no access. The route then heads south over an open pass with moderate terrain to meet the fourth option at point 43 which follows McKendrick Creek to Telkwa Substation.

(iv) Iskut Canyon-Skeena Substation

The several alternative routes possible between Iskut Canyon generating station and Skeena Substation are described in Section 3.4(a), Scheme I (viii).

(c) Scheme III

Scheme III is similar to Scheme I except the transmission line route from Iskut Canyon generating station to Skeena Substation is

replaced by a route from Iskut Canyon to Telkwa Substation and from Telkwa Substation to Skeena Substation. As route alternatives from Iskut Canyon to Telkwa Substation have been discussed in Section 3.4(a), Scheme I (iv), (v), (vi) and (vii) only route alternatives between Telkwa and Skeena substations will be discussed here.

(i) Telkwa Substation-Skeena Substation

There are two main route alternatives between these substations. As seen on Plate 3-1, Sheet 1, one route (segments 32-31-29-59-27-24-25-18) is generally adjacent to the north side of the existing 500 kV transmission line (circuit 5L63). The terrain along this route has proved to be difficult such that expensive, rigid towers are necessary over a major portion. The timber is dense and access is available in most places by utilizing the existing transmission line. A massive area of hillside just west of point 29 under the existing line is slowly slipping into the valley. The area is approximately 0.5 km by 2 km long but could easily be avoided by a second line. The segment 24-25 is narrow and congested with existing linear development. This portion could be avoided by a route segment along Williams Creek (segment 27-28-25-18). This route would follow Clore River and Trapline Creek along segment 27-28, and through a pass between Trapline Creek and Williams Creek at point 28. Williams Creek has considerable access near its mouth and increases as logging progresses.

The other route to the south (32-31-33-28-25-18) skirts the north side of the Telkwa Range and heads southwest over rough terrain to intercept the Burnie River as it flows out of Burnie Lake near point 33. The route then crosses the Burnie River and traverses a high mountain pass with bare, rugged terrain where severe wind and icing conditions are expected. The route then continues through heavy forest cover, crosses

the Clore River and meets the Williams Creek route at point 28. The only available access is a small amount at either end of the route.

(d) Scheme IV

Scheme IV is similar to Scheme II except the transmission line route from Iskut Canyon generating station to Skeena Substation is replaced by a route from Iskut Canyon to Telkwa Substation and from Telkwa to Skeena Substation. Route alternatives from Iskut Canyon to Telkwa Substation have been discussed in Section 3.4(a), Scheme I (iv), (v), (vi) and (vii). Route alternatives between Telkwa and Skeena substations have been discussed in Section 3.4(c) Scheme III (i). Therefore, no further route descriptions are necessary.

(e) Scheme V

In Scheme V, a tie to the existing system would occur at a proposed station near Cluculz Lake, approximately 50 km west of Prince George and Skeena Substation rather than at Telkwa and Skeena Substation as in the previous schemes. An intermediate station would be required at the approximate mid-point between the Stikine Collector and the proposed Cluculz Station. The potential site of Cluculz Station is shown on Plate 3-1, Sheet 2.

A route from the Stikine Collector through the Klappan River valley to the Nass River valley is common with that noted earlier for Schemes II and IV along segments 2-3-34-35 (Section 3.4(b)(i)). At the Nass River (point 35) two alternate routes exist. One route proceeds along the British Columbia Railway (BCR) route in the Skeena River valley. The other route continues along the routes previously described for Schemes II and IV (Section 3.4(b)(iii))

View north up the Shelagyote River Valley north of Babine River. Gumanoot Lake is at the right. (Segment 39-43)

View west down the Driftwood River Valley and the B.C. Rail route near Bear Lake. (Segment 58-48)

past the possible Muckaboo Collector and through to Babiche Hill at point 39 on the Skeena River.

(i) Stikine Collector - Cluculz via BCR Route
(Refer to Plate 3-1, Sheets 1 and 2)

This route follows the BCR Dease Lake route along segments 34-35-44-58-60-48-49-50-51-52. It remains generally to the north of the existing railroad grade. As noted earlier the route avoids the Little Klappan River valley because it is too narrow and avalanche swept. At Trembleur Lake the route bends to the north of Tezzeron Lake before turning south towards the proposed Cluculz Station.

There is access along much of this route by using the BCR sub-grade, rail extension and existing logging in the southern portion.

(ii) Stikine Collector - Cluculz via South Route

This route makes use of route segments previously described in Scheme II Section 3.4(b)(i) and (iii) from point 39 to 43 on the Babine River east of the Babine Range and due north of the Telkwa Substation. From point 43 it continues in a southeasterly direction between Stuart and Babine lakes to the proposed Cluculz Station along segments 43-47-53-55-51-52.

An alternate route in the northern portion of the south route would head east from Babiche Hill at point 39 and follow the Skeena River to point 45 where it joins the south route connection described in the next section (segments 45-46-47).

Throughout this region the terrain is variable with wide valleys.

View of Cunningham Lake looking east. (Segment 47-53)

View east up the Sutherland River near the southeast end of Babine Lake. (Segment 53-51)

The southern portion of this route has a considerable amount of existing logging activity.

(iii) BCR Route - South Route Connections

Two connecting routes are shown on Plate 3-1, Sheet 2 between the BCR route and the south route. They lie on either side of the Bait Range and allow the opportunity to change from one general route to the other.

The connecting route to the east of the Bait Range heads south from the BCR route at point 48 along segments 48-54-53 to Cunningham Lake. This route traverses flat to rolling terrain through a region where some logging is in progress and access is being established.

West of the Bait Range a connecting route heads south at point 58 near Mosque Mountain and follows segments 58-45-46-47 along the wide Squingula River valley and the Nilkitkwa River. The region has some swamps and no existing access. Most of the route through the Squingula River valley traverses an old forest fire area.

Similarly, there is a connecting route to change from the south route to the BCR route. This can be done by following the north side of the Skeena River east, from point 39 at Babiche Hill along segments 39-45-60. This route would necessitate crossing the Skeena and Bear rivers. Both river valleys are wide with easy terrain. There is no access along the Skeena River portion.

(f) Scheme VI

The same route alternatives are available in Scheme VI as those described in Scheme V. Some areas may require further field examination to determine suitability for three lines.

SPATSIZI WILDERNESS PARK

PROPOSED STIKINE COLLECTOR

POSSIBLE MUCKABOO COLLECTOR

BOB QUINN ECOLOGICAL RESERVE

MORE CREEK

PROPOSED BOB QUINN COLLECTOR

PROPOSED FORREST KERR DIVERSION DAM

ISKUT CANYON

MEZIADIN

KITSAULT

TEEKWA SUBSTATION

SKEENA SUBSTATION

STUDY AREA

KEY PLAN

SCALE OF KILOMETRES

0 10 20 30 40 50

LEGEND

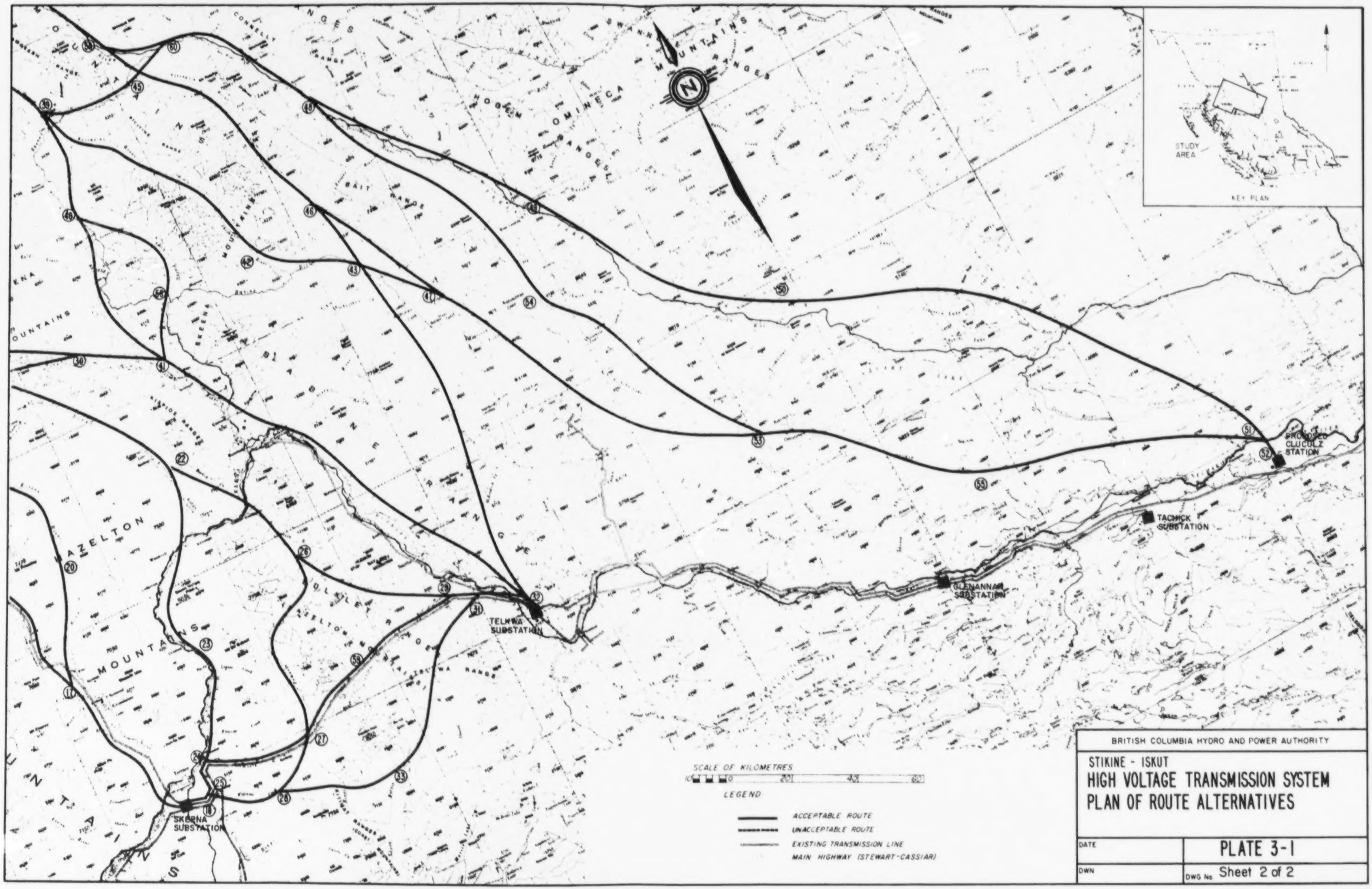
- ACCEPTABLE ROUTE
- UNACCEPTABLE ROUTE
- EXISTING TRANSMISSION LINE
- PROPOSED GENERATION SITE
- MAIN HIGHWAY (STEWART - CASSIAR)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM PLAN OF ROUTE ALTERNATIVES

DATE	PLATE 3-1
DWN.	DWG No. Sheet 1 of 2



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM PLAN OF ROUTE ALTERNATIVES

DATE	PLATE 3-1
DWN	DWG No. Sheet 2 of 2

SECTION 4.0 - ROUTE EVALUATION

4.1 INTRODUCTION

To establish the technical feasibility and economic viability of the main routes that comprise the four different schemes, all segments noted have been studied and evaluated.

Topographic maps published by the Provincial and Federal governments were assembled for the study area. These were analyzed to identify potentially feasible routes and route segments. Obvious social and environmental constraints and modifiers such as parks, recreational areas and residential communities were considered in the determination of the feasible routes. A full environmental evaluation of the feasible routes is detailed in an environmental report prepared concurrently by an independent consultant titled "Preliminary Environmental and Social Impact Assessment of the Stikine-Iskut Transmission System.

Aerial photographs of parts of the study area were assembled next. The topographic features of the route segments were further analyzed with these photographs. Areas appearing technically difficult and/or hazardous were marked for close examination during the field reconnaissance. The field reconnaissance included mostly fixed wing and helicopter examinations of the entire study area. Topographic maps of areas of specific concern were made to a larger scale than normally available. From this large scale mapping a more accurate assessment of route segment feasibility was determined.

The avalanche hazard in the triangular region bounded by the proposed Bob Quinn Collector, Iskut Canyon Dam and Bell-Irving River/Taft Creek confluence was evaluated by an independent consultant retained by B.C.

Hydro to assess route feasibility relative to numerous avalanches that occur in that part of the study area.

Following the office and field study, the feasible routes and route segments were evaluated and compared on the basis of line length, construction cost and transmission line security. The following sub-sections elaborate on this evaluation and comparison.

It should be noted that the systems involving three lines on the same route were not identified until the preliminary engineering field work had been completed. Therefore cost estimates were prepared on the basis of the evaluations for two lines and further field work would be required to verify the acceptability of three lines on some route segments.

4.2 TECHNICAL EVALUATION

Table 4-1 is a compilation of the components that reflect the relative cost of constructing a transmission line. Each of the four evaluation components has five ratings ranging from low to extreme. After a comprehensive study of all of the routes and subroutes a rating for each of the components with reference to Table 4-1 was given to each of the segments.

The ratings given to each of the segments together with segment lengths are listed in Table 4-2.

A description of the four evaluation components of Table 4-1 is as follows:

1. Design - There are three main independent factors influencing the design component. Each segment was rated according to the factor

warranting the most severe rating. The factors for consideration are:

a. Topography - The more severe the sideslope the more difficult and expensive the line is to construct. In order to maintain proper clearance taller structures are necessary or structure spacing is reduced and as a result more structures are required. Longer leg extensions on the structures are necessary and structure sites need more preparation, such as benching.

b. Loading - If severe ice and wind loadings are anticipated the conductor and structures must be heavier, resulting in higher costs.

c. Percentage of Deflections - Changes in transmission line direction require heavier structures. Consequently, the greater the percentage of large deflection angles the more expensive the line becomes.

2. Access - The ratings for access reflect the availability of roads for the construction and maintenance of the transmission line. Good access is conducive proper preventative maintenance and resulting system reliability. The time and effort required for emergency repairs is also reduced by adequate access which ultimately results in cost savings. An area will warrant a low rating where good access already exists from logging and linear developments such as other transmission lines, pipelines or highways. The ratings will increase as the availability of existing roads decreases and as new access becomes increasingly difficult to construct. Regions where linear access is available but where access to individual tower sites would be difficult are also rated high. Areas that are considered to be inaccessible to vehicles are given the highest ratings.

3. Clearing - The ratings for the clearing component increase as the difficulty and cost of clearing the right-of-way increases. Areas that cannot be cleared by machinery due to their sensitivity to erosion, steep side slopes, wetness, or final appearance and must therefore be cleared by hand held equipment, are given high ratings. Logged areas are rated low because of the reduced clearing required.

4. Special Considerations - Specialized structures or construction techniques are special considerations which result in higher costs. This includes items such as spans exceeding 1500 m, structure legs designed to withstand snow movement (snow legs), avalanche protection, special structures such as single phase towers and double circuit towers, or anything else that would warrant specialized construction.

4.3 COST ESTIMATES

The costs associated with constructing a transmission system (i.e. transmission lines and stations) can be separated into direct costs and indirect costs. Direct costs include:

1. Engineering,
2. Right-of-Way acquisition,
3. Clearing,
4. Materials,
5. Construction,
6. Isolation costs for remote areas (where applicable),
7. Contingencies (such as pile footings, special crossings, snow legs, etc.)

Indirect costs include:

1. Inflation,
2. Corporate overhead,
3. Interest during construction.

Transmission line direct costs for each of the segments examined, except Stikine Canyon to Stikine Collector (point 2), are shown in Table 4-3. These costs have been calculated based on the four technical evaluation components discussed in Section 4.2. The Stikine Canyon to Stikine Collector segment is about 2 km in length and could involve intricate design modifications to cross the reservoir and dam. Therefore a cost estimate for this segment would be premature at this stage of the study but will be the same for all schemes.

The costs shown in Table 4-3 are estimates calculated using known 1981 construction costs for similar transmission lines. Additional cost factors were included in the estimates to account for the remoteness of this transmission line system. These direct cost estimates are included in this report primarily to provide a cost comparison between segments and are not intended to be a detailed total cost estimate. Some segments have been added together for convenience.

Once a direct cost estimate is calculated for a given scheme the indirect costs can be added. Indirect cost estimates are based on the planned in-service date and predictions of economic conditions in the future. Therefore, indirect costs are not included in the values presented in Table 4-3. Station costs are also not included in Table 4-3 as they would remain similar regardless of which segments comprise the route.

Station costs associated with each scheme proposal are shown in Table 5-1 as the Total Direct Station Cost Estimate. The large difference of $17.5 million between station costs for Schemes 1 and 2 is the result of what the station would do. Basically both stations perform similar functions and carry a similar number of transmission

lines with one significant difference. The Bob Quinn Collector in Scheme 1 has provision for voltage step-down transformation to provide local electrical supply whereas Muckaboo does not. The additional equipment required to perform this function increases the overall cost of the station. This is also the reason for the difference between Schemes 3 and 4. The cost increases in Schemes 5 and 6 are caused by more stations required to cover the longer distances.

The sum of direct costs and indirect costs for transmission lines and associated stations for the preferred technical route alternative for each scheme is shown in Table 5-1 as the total cost estimate. It should be noted that a voltage higher than 500 kV may be selected for transmission between Stikine Collector and the proposed Cluculz Station which would significantly increase costs for Schemes 5 and 6.

This total cost estimate does not include annual costs such as line losses, operation and maintenance and taxes which are incurred after the line is in service.

4.4 SECURITY EVALUATION

Security evaluation is an estimate of the remaining vulnerability of tower sites after designing for predicted hazards. Table 4-4 contains the six major hazards considered in evaluating the security of the transmission line routes. Each hazard has five severity ratings ranging from low to extreme depending on the criteria described in the table. Each of the route segments has been evaluated for all of these security hazards. Table 4-5 is a tabulation of the segment hazard ratings. The assessment of the security of the route alternatives was made with reference to this table.

The security hazard rating for any route alternative cannot be calculated arithmetically from these segment ratings. This is due to the

varying relative significance and unrelated nature of the six hazards. The assessment of the security of the route alternatives was based on engineering judgement and experience with transmission line construction and maintenance.

A brief description of the security hazards of Table 4-4 is as follows:

1. Avalanche - Snow avalanches can be severe hazards to transmission lines because of their high velocities, high impact pressures and associated air blasts and debris carrying characteristics. Areas prone to avalanches generally have high local relief and abundant snowfall. Conditions critical for avalanche formation are slopes which average 20° to 35° and where the upper reaches or "starting zones" are prone to snow accumulation of at least 1.5 m by either direct precipitation or by wind accumulation.

   Avalanches usually flow in a defined track between the starting zone at the top and a runout zone at the bottom. These tracks can either be confined to a gully or be on unconfined planar open slopes. Starting zones must have the required steepness of 20° to 35°, however, avalanche tracks may include gentle slopes or level terrain. The runout zone is usually the valley floor but may extend up the opposite valley wall.

   If it is not possible to avoid avalanche areas the towers should be located between the avalanche tracks on high points of the terrain. In order to protect individual tower sites large berms can be made immediately uphill of the site to divert the snow around the tower. Berms are usually constructed on site using local materials such as earth or rock and heavy construction equipment. Heavy supporting members, called snow legs, are also used to secure the tower against flowing snow and debris.

2. Slope Failure - There are numerous types of slope failures which can damage a transmission line. These include large scale rock and earth slides, debris flows and small scale slope failures usually caused by construction or logging activities. Areas with high local relief and abundant precipitation are particularly susceptible to slope failures. Slope failures also occur on gentle slopes underlain by sensitive materials such as marine sediments and clayey till.

Large scale landslides must be avoided by transmission lines because tower footings embedded in a landslide may undergo differential movements which can cause destructive stresses on the structure. Also, access road construction and clearing may aggravate the soil movement by reducing the strength of the landslide material and disrupting drainage. These activities may also cause small scale slope failures on previously stable ground underlain by sensitive silts and clays.

Debris flows, the rapid downslope movement of water saturated soil and forest debris, are particularly destructive to transmission lines. They are caused by the failure of a thin surface layer of water saturated, weathered and broken rock on steep slopes, underlain by bedrock. Debris flows usually occur on logged slopes of approximately 35° and in areas of intense rainfall. Slopes susceptible to this type of failure should be avoided or special care taken in the construction and clearing activities.

3. Floods and River Erosion - Flooding and river erosion rank high in their destructive capability to transmission lines. Flood waters can undermine tower footings or cause damage with floating logs and debris. River banks can be eroded hundreds of metres in a single flood and small creeks can become raging torrents in a few hours during heavy rainstorms and snowmelt.

Securing towers against flood and erosion damage can be difficult, expensive and environmentally undesirable. Typical security methods include surrounding towers with a sheet pile wall filled with rock, use of pile footings, placement of riprap, erection of dikes and diversion or modification of stream channels.

4. Ice and Wind Loading - Significant consideration must be given to ice and wind loading during transmission design and route selection. Ice accumulation and wind loading can cause collapse of a transmission line.

Large amounts of ice can form when fog or clouds surround structures and conductors at temperatures well below freezing or when moisture is deposited by freezing rain or drizzle in conjunction with freezing temperatures.

Strong winds and gusts can cause damage by imposing high loads on structures and conductors either by direct force or by setting the conductor in motion causing circuit interruptions due to contact between conductors. Severe ice and wind loading can occur simultaneously and their combined effect can be devastating to transmission structures.

Ice and wind loadings are a complex meteorological phenomena. Areas prone to such conditions are difficult to outline without extensive long-term measurement and testing. However, certain terrain features and ambient air temperatures exercise considerable influence on the phenomena. Areas to avoid in transmission line construction are exposed ridges and narrow passes at high elevations where wind speeds are high and where passing clouds can envelope the structures. In coastal areas susceptible to cold northern air masses severe ice and wind conditions can occur at considerably lower elevations particularly where warm air can mix with or trap colder air in depressions and valleys.

Protection against ice and wind loading is restricted to installing stronger towers and conductors. These measures are extremely costly and complete security cannot always be ensured. Therefore, areas of suspected extreme ice and wind conditions should be avoided.

		RATINGS				
		LOW → EXTREME				
		I	II	III	IV	V
EVALUATION COMPONENTS	DESIGN CONSIDERATIONS - Topography - Conductor Loading - Deflections	- no sidehill - light loading - low percent of defl	- rolling, some sidehill - light loading - medium percent of defl	- 30° average sidehill - medium loading - med-high percent of defl	- over 30° average sidehill - high loading - high percent of defl	- extreme sidehill - extreme loading - individual site selection
	ACCESS	Good existing access from other linear developments	Access to R/W at frequent points not far from existing roads. New road construction easy	Some access; new road construction possible	No existing access; new road construction difficult	Inaccessible to vehicles
	CLEARING	Little clearing; range land with scattered individual trees	Easy machine clearing	Moderate machine clearing; some hand clearing	Extensive hand clearing; forests that will not be logged	Totally hand clearing; steep, densely forested slopes
	SPECIAL CONSIDERATIONS	None	minimal	moderate	high	extreme

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STIKINE - ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
TECHNICAL EVALUATION TABLE

DATE	TABLE 4-1
DWN	DWG No

SEGMENT	LENGTH (km)	EVALUATION COMPONENTS			
		DESIGN CONSIDERATIONS	ACCESS	CLEARING	SPECIAL CONSIDERATIONS
1-2	25	II	III	II	II
2-3	11	I	I	II	II
2-4	87	II	III	II	II
2-34	55	II	III	II	II
3-4	60	II	I	II	II
3-35	19	II	III	III	I
4-5	54	II	II	II	II
5-6*	11*	I	I	II	II
5-7	20	II	II	II	I
5-34	65	IV	I	IV	V
6-8*	29*	II	III	III	I
7-8	4	IV	V	V	V
8-9	14	IV	V	V	II
9-10	20	III	V	V	II
10-11	18	III	IV	III	III
11-12	11	IV	IV	IV	IV
12-13	21	III	III	III	I
13-14	42	III	I	III	II
13-15	48	II	II	III	II

*230 kV 1/0 ONLY

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 4-1 TECHNICAL EVALUATIONS TABLE

SEGMENT	LENGTH (km)	EVALUATION COMPONENTS			
		DESIGN CONSIDERATIONS	ACCESS	CLEARING	SPECIAL CONSIDERATIONS
13-36	56	III	III	III	III
15-16	100	II	III	II	II
15-19	75	II	III	II	II
15-21	48	I	III	II	II
16-17	52	III	I	III	I
16-19	32	II	II	II	I
17-18	50	II	I	II	I
17-20	36	III	II	II	III
18-25	10	I	II	II	II
19-20	45	III	IV	III	III
21-22	69	II	I	II	II
21-30	34	II	I	II	II
21-57	21	I	III	II	II
22-23	62	II	II	III	I
22-26	51	II	I	II	II
23-24	38	III	II	III	I
24-25	10	IV	IV	III	I
24-27	33	III	II	III	II
25-28	24	II	III	III	II
26-27	60	II	III	II	II

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STIKINE - ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
TECHNICAL RATINGS

DATE	TABLE 4-2
DES	DWG No SHEET 1 OF 2

SEGMENT	LENGTH (km)	EVALUATION COMPONENTS			
		DESIGN CONSIDERATIONS	ACCESS	CLEARING	SPECIAL CONSIDERATIONS
26-29	48	I	I	II	I
27-28	20	II	III	III	II
27-59	21	III	III	IV	II
28-33	13	II	II	II	II
29-31	7	I	I	II	I
29-59	40	II	II	II	II
30-41	28	II	I	II	II
30-57	48	II	I	II	I
31-32	19	I	I	II	I
31-33	61	II	III	II	I
32-41	140	II	II	II	I
32-43	119	II	II	II	I
34-35	63	II	III	II	II
35-36	72	II	III	III	II
35-44	81	II	II	II	II
36-37	20	II	III	III	II
36-38	47	II	III	II	II
37-38	41	II	III	II	II
37-39	44	II	III	III	II
38-57	39	I	III	II	II
39-40	34	III	III	III	II
39-42	80	III	IV	II	II

*230 kV T/L ONLY

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 4-1 (TECHNICAL EVALUATION TABLE)

SEGMENT	LENGTH (km)	EVALUATION COMPONENTS			
		DESIGN CONSIDERATIONS	ACCESS	CLEARING	SPECIAL CONSIDERATIONS
39-45	33	II	III	III	II
40-41	57	II	III	II	II
40-56	44	II	III	II	II
41-56	20	I	II	II	I
42-43	11	I	III	II	I
43-46	22	I	III	II	I
43-47	25	I	II	II	I
44-58	48	II	I	II	I
45-46	70	II	III	II	II
45-58	86	II	I	II	I
45-60	13	III	II	II	II
46-47	46	I	I	II	I
47-59	114	II	I	II	I
48-49	80	II	II	II	II
48-54	96	I	II	II	I
48-60	47	III	II	II	II
49-50	85	III	III	III	II
50-51	100	II	III	II	II
51-52	6	I	I	II	I
51-55	88	II	II	II	I
53-54	84	I	II	II	I
53-55	69	II	III	II	II
58-60	24	III	II	II	II

BCHydro

STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM

TECHNICAL RATINGS

DATE	TABLE 4-2
DWN	DWG. No. SHEET 2 OF 2

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
1-2	25	2	20069
2-3	31	2	19505
		3	28393
		5	46041
2-4	87	2	75968
2-3-4	91	2	67013
2-34	55	2	46316
		3	68068
2-3-34	50	2	35262
3-4	60	1	24720
		2	47508
3-34	19	2	15757
		3	23030
4-5	46	1	17654
		2	32813
5-6*	11	1*	1526
5-7-8-9	38	1	24053
		2	46615
5-14-13	77	1	44348
		2	86726
		DOUBLE CIR.	92906
		DOUBLE + 1	135284
6-8-9*	43	1*	9976

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
9-10-11-12-13	92	1	62246
		2	115121
13-15	48	1	18817
		3	53237
13-36	56	1	33780
		2	63069
15-16	100	1	45380
15-19	75	1	29770
15-21	48	1	20036
		2	37567
		3	55098
16-17	52	1	23432
16-19	32	1	14420
17-18	50	1	17593
17-20-19	81	1	38896
18-25	10	1	3285
21-22	69	1	21990
		2	42307
		3	62624
21-30	34	1	13777
		2	26345
		3	39242
21-57	21	2	16925

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
21-57	21	3	24394
22-23-24	100	1	61144
22-26	51	1	21182
		2	40167
		3	59152
24-25	10	1	5890
24-27	33	1	14404
25-28	24	1	9213
26-27	60	1	24996
26-29	48	2	29834
		3	44402
27-28	20	1	7622
27-59-29	61	1	23798
28-33-31	98	1	47204
29-31	7	1	2181
		2	4332
		3	6482
		4	8634
30-41	28	1	11558
		2	21945
		3	32604
30-57	48	2	37580
		3	55851

* 230 kV T/L ONLY

NOTES:

1. COST ESTIMATES ARE BASED ON CONSTRUCTION OF 500 kV SINGLE CIRCUIT TRANSMISSION LINES IN OTHER PARTS OF B.C.
2. DOUBLE CIRCUIT 500 kV COST ESTIMATE SHOWN FOR SEGMENT 5-14-13.
3. INFLATION, CORPORATE OVERHEAD AND INTEREST DURING CONSTRUCTION ARE NOT INCLUDED IN THESE COST ESTIMATES.

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STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM
DIRECT COST ESTIMATES

DATE | TABLE 4-3

DWN. | DRG. NO. SHEET 1 OF 2

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
31-32	19	1	5920
		2	11757
		3	17595
		4	23431
32-41	140	2	100675
		3	149387
32-43	119	2	87063
		3	128670
34-35	83	2	69022
		3	98626
35-36	72	2	61312
		3	89578
35-44-58	149	2	118061
		3	173253
36-37	20	2	17509
		3	25549
36-38	47	2	42509
		3	61268
36-37-38	61	2	52043
		3	76001
37-38	41	2	34534

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
37-38	41	3	50452
37-39	44	2	38486
		3	56174
38-57	39	2	31429
		3	45298
39-40	34	2	34706
		3	50760
39-42-43	111	2	103871
		3	150575
39-45	33	2	28917
		3	42182
40-41	57	2	45298
		3	66997
40-56-41	64	2	48706
		3	71768
43-46	22	2	15828
		3	23248
43-47	25	2	18126
		3	26557
45-46	70	2	56373
		3	81993

SEGMENT	LENGTH (km)	NUMBER OF LINES	COST $ x 1000
45-58	16	2	12413
		3	18348
45-60	13	2	12586
		3	17943
46-47	46	2	32665
		3	48097
47-53	114	2	81224
		3	119557
48-49-50-51	325	2	257393
		3	381306
48-54-53	180	2	125018
		3	183568
48-60	47	2	43445
		3	64874
51-52	6	2	3704
		3	5505
51-55-53	157	2	112751
		3	165786
58-60	24	2	22184
		3	33126

NOTES:

1. COST ESTIMATES ARE BASED ON CONSTRUCTION OF 500 KV SINGLE CIRCUIT TRANSMISSION LINES IN OTHER PARTS OF B.C.
2. DOUBLE CIRCUIT 500 KV COST ESTIMATE SHOWN FOR SEGMENT 5-14-13.
3. INFLATION, CORPORATE OVERHEAD AND INTEREST DURING CONSTRUCTION ARE NOT INCLUDED IN THESE COST ESTIMATES.

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STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM
DIRECT COST ESTIMATES

DATE | TABLE 4-3

DWN. | DWG. No. SHEET 2 OF 2

		I ZERO - VERY LOW	II LOW	III MODERATE	IV HIGH	V EXTREME
AVALANCHE		LITTLE SNOW ACCUMULATION. SLOPES < 10°-15°. TREE COVERED REMOTE POSSIBILITY OF OCCURRENCE	SNOW ACCUMULATION < 1.5 m SLOPE ANGLES < 20° OR > 50° NO EXISTING AVALANCHE PATHS. POSSIBILITY OF OCCURRENCE ON OPEN SLOPE DURING UNUSUALLY HEAVY SNOW FALL	STARTING ZONE - SNOW DEPTH > 1.5 m - SLOPE ANGLE 20°-50° - TREE COVERED A FEW CONFINED AVALANCHE PATHS. POSSIBILITY OF SPARSE TO PASSING DEAD ENDS OF RUNOUT ZONES	STARTING ZONE:-SNOW DEPTH > 1.5 m -SLOPE ANGLE 20°-50° -LACK OF TREES NUMEROUS, CONFINED AVALANCHE PATHS AT LEAST ONE LARGE AVALANCHE/PATH/YR AVOIDANCE OF MOST PATHS DIFFICULT	STARTING ZONE:-SNOW DEPTH > 1.5 m -SLOPE ANGLE 20°-50° -LACK OF TREES NUMEROUS, INTERMINGLING OF UNCONFINED AVALANCHE PATHS. MORE THAN ONE LARGE AVALANCHE/PATH/YR. NO POSSIBILITY OF SPARING OR AVOIDING PATHS.
SLOPE FAILURE	LANDSLIDE	FLAT TO MODERATE TERRAIN WELL DRAINED, GENERALLY UNCONSOLIDATED MATERIAL ON BEDROCK	FLAT TO MODERATE TERRAIN, FLOOD PLAIN, FAN OR DELTA. GENERALLY WELL DRAINED BUT MATERIAL NOT HOMOGENEOUS CAUSING LOCALIZED AREAS OF POOR DRAINAGE.	HILLY, GLACIATED TERRAIN-SUMERIAN SHARPS LAKES, MEANDERING STREAMS. INTERBEDDED MATERIALS, DRAINAGE GENERALLY POOR. EXISTING FAILURES SMALL.	HILLY, GLACIATED TERRAIN, OLD LANDSLIDE DEPOSITS, INTERBEDDED MATERIALS OF HIGHLY VARYING PERMEABILITY, POOR DRAINAGE, SLOPES UNDERCUT BY EROSION, SOME LARGE EXISTING FAILURES.	AREA OF EXTENSIVE, RECENT LANDSLIDE ACTIVITY CHARACTERIZED BY TENSION CRACKS, BLOCKED DRAINAGE, SEEPAGE ZONES AND ABNORMAL GROUND, MATERIAL CONTAINS FINE GRAINED SILT AND CLAY OR WEATHERED SHALE. AREA CANNOT BE AVOIDED.
	DEBRIS (MUD) FLOW	TERRAIN FLAT TO GENTLY ROLLING THICK SOIL MANTLE OVERLYING BEDROCK. MATERIAL WELL DRAINED. LIGHT RAINFALL OR SNOWMELT.	FLAT TO MODERATE TERRAIN WITH SLOPES < 25°, THIN MANTLE OF SOIL OVERLYING BEDROCK. LIGHT RAINFALL AND SNOWMELT.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK, POOR-MODERATE DRAINAGE. TREECOVER NOT REMOVED, PERIODS OF HEAVY RAINFALL, NO PREVIOUS SLIDES VISIBLE.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK, POOR DRAINAGE. AREA SUBJECT TO HIGH INTENSITY RAINFALL. TREE-COVER REMOVED BUT GROUNDCOVER RE-ESTABLISHED. SOME PREVIOUS SLIDES VISIBLE.	STEEP TERRAIN WITH SLOPES > 25° THIN MANTLE OF SOIL OVERLYING BEDROCK, POOR DRAINAGE. AREA SUBJECT TO HIGH INTENSITY RAINFALL AND SNOWMELT. TREECOVER RECENTLY REMOVED OR SOIL MANTLE DISTURBED. NUMEROUS PREVIOUS SLIDES VISIBLE.
	ROCKFALL	FLAT TO GENTLY ROLLING TERRAIN. UNCONSOLIDATED MATERIAL ON GENTLY ROLLING BEDROCK AREAS.	GENTLY ROLLING TERRAIN WITH MODERATE SLOPES CONSISTING OF MASSIVE DISCONTINUOUSLY JOINTED ROCK NOT SUSCEPTABLE TO EROSION.	STEEP ROCK SLOPES > 25°, FAVOURABLE ORIENTATION OF JOINTS AND BEDDING. FEW FAULT ZONES, EXISTING ROCKFALLS CONFINED TO GULLIES AND GULLIES. SLOPE NOT UNDERCUT BY EROSION. SOME POSSIBILITY OF AVOIDING EXISTING ROCKFALLS.	STEEP ROCK SLOPES > 25°, UNFAVOURABLE ORIENTATION OF JOINTS OR BEDDING. NUMEROUS FAULT ZONES AND EXISTING ROCKFALLS. SLOPES NOT UNDERCUT BY BY EROSION ETC. SOME POSSIBILITY OF AVOIDING EXISTING ROCKFALLS.	STEEP ROCK SLOPES > 25°, UNFAVOURABLE ORIENTATION OF JOINTS OR BEDDING. NUMEROUS FAULT ZONES AND EXISTING ROCKFALLS. SLOPE UNDERCUT BY RIVER EROSION OR CONSTRUCTION ACTIVITY. GREAT DIFFICULTY OF AVOIDING EXISTING ROCKFALLS.
FLOOD AND RIVER EROSION		FLAT TO GENTLY ROLLING TERRAIN. A FEW WELL CONFINED STREAMS WITH REMOTE POSSIBILITY OF FLOODING OR COURSE CHANGE.	MODERATE TO STEEP TERRAIN. FEW INTERSECTING STREAMS WITH SOME POSSIBILITY OF FLOODING OR COURSE CHANGE.	OBLIQUE CROSSING OF WIDE FLOODPLAIN OF MAJOR CREEK OR RIVER PRONE TO FLOODING. A FEW STRUCTURES REQUIRED ON FLOODPLAIN OR SOME INTERSECTING STREAMS PRONE TO FLOODING OR COURSE CHANGE. SOME POSSIBILITY OF AVOIDANCE.	LINE LOCATED ON FLOODPLAIN, MOUNTAINOUS TERRAIN PRONE TO HIGH INTENSITY RAINFALL AND SNOWMELT. RIVER CHANNEL GENERALLY CONFINED BUT PRONE TO COURSE CHANGE. LINE CROSSES PORTION OF NUMEROUS STREAMS SUBJECT TO FLOODING OR COURSE CHANGE	LOCATED ON FLOODPLAIN, MOUNTAINOUS TERRAIN PRONE TO HIGH INTENSITY RAINFALL AND SNOWMELT. RIVER CHANNEL UNCONFINED AND PRONE TO PERIODIC COURSE CHANGE. FLOODPLAIN STREAM WITH DEBRIS.
ICE AND WIND LOADING		COMPLETELY SHELTERED. AIR MASSES GENERALLY DRY. TEMPERATURES RARELY BELOW FREEZING.	GENERALLY SHELTERED AND AT LOWER ELEVATIONS. SOME EXPOSURE TO MOIST AIR. PERIODIC TEMPERATURES BELOW FREEZING.	GENERALLY EXPOSED TO PREVAILING WIND AND/OR MOIST AIR MASSES. SUSTAINED TEMPERATURES BELOW FREEZING.	MOSTLY EXPOSED TO PREVAILING WIND AND MOIST AIR MASSES. SUSTAINED TEMPERATURES BELOW FREEZING. LINE OBLIQUE OR PARALLEL TO PREVAILING WIND & GENERALLY ABOVE TREELINE OR AREA PRONE TO ENTRAPMENT OF COLD ARCTIC AIR BY MOIST COASTAL AIR.	COMPLETE TRANSVERSE EXPOSURE TO HIGH VELOCITY, PREVAILING WINDS. MOIST AIR MASSES AND SUSTAINED TEMPERATURES BELOW FREEZING.

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STIKINE - ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
SECURITY EVALUATION TABLE

DATE	TABLE 4-4
DWN	DWG No

SEGMENT	HAZARD					
	AVALANCHE	SLOPE FAILURE			FLOODS (RIVER) EROSION	WIND & ICE LOADING
		LAND-SLIDE	DEBRIS-MUD FLOW	ROCK FALL		
1-2	I	I	I	I	I	II
2-3	I	I	I	I	I	II
2-4	II	II	II	I	II	II
2-34	I	II	II	I	I	II
3-4	II	I	II	II	II	III
3-34	I	II	II	I	III	II
4-5	II	II	II	I	II	III
5-6*	I	III	I	I	III	III
5-7	III	II	III	III	I	III
5-14	IV	III	I	I	II	III
6-8*	III	II	III	III	I	III
7-8	II	II	III	III	I	III
8-9	III	II	III	III	I	III
9-10	IV	II	III	III	III	II
10-11	II	I	I	I	I	IV
11-12	IV	III	III	II	II	IV
12-13	II	II	I	I	II	II
13-14	II	II	II	I	II	III
13-15	II	II	II	I	II	III

*230 kV T/L ONLY

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 4-4 (SECURITY EVALUATION TABLE)

SEGMENT	HAZARD					
	AVALANCHE	SLOPE FAILURE			FLOODS (RIVER) EROSION	WIND & ICE LOADING
		EARTH-FLOW	DEBRIS-MUD SLIDE	ROCK-FALL		
14-16	III	III	III	II	II	IV
15-16	I	II	II	I	II	II
15-19	I	I	II	II	II	II
15-21	I	II	I	I	II	II
16-17	I	II	II	II	II	II
16-19	I	I	II	II	II	II
17-18	I	II	II	I	III	II
17-20	III	III	II	II	I	II
18-25	I	I	I	I	I	I
19-20	III	III	III	II	II	III
21-22	I	II	I	I	II	II
21-30	I	I	I	I	I	II
21-37	I	III	II	II	II	II
22-23	I	IV	IV	III	II	II
22-36	I	II	I	I	II	II
23-24	I	IV	IV	III	IV	II
24-25	I	I	IV	IV	IV	II
24-27	II	III	III	III	IV	II
25-28	III	III	III	II	II	II
26-27	I	II	I	I	I	II

BC Hydro

STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM

SECURITY RATINGS TABLE

DATE

TABLE 4-5

SHEET 1 OF 2

SEGMENT	HAZARD					
	AVALANCHE	SLOPE FAILURE			FLOODS (RIVER) EROSION	WIND & ICE LOADING
		LAND-SLIDE	DEBRIS-MUD FLOW	ROCK-FALL		
26-29	I	II	I	I	II	II
27-28	III	I	II	II	II	II
27-59	III	III	III	III	III	II
28-33	III	I	II	II	II	IV
29-31	I	I	I	I	I	I
29-59	I	III	III	II	II	II
30-41	I	I	I	I	I	II
30-57	I	I	I	I	I	II
31-32	I	I	I	I	I	I
31-33	I	I	I	I	I	II
32-41	I	I	I	I	I	II
32-43	I	II	II	I	I	II
34-35	II	II	II	I	III	II
35-36	I	II	II	I	III	II
35-44	III	III	III	II	II	III
36-37	I	II	II	I	II	II
36-38	I	II	II	II	II	II
37-38	II	II	II	I	I	II
37-39	II	II	II	I	II	II
38-57	I	III	II	II	II	II
39-40	I	II	II	I	II	II
39-42	I	III	III	II	II	II

SEGMENT	HAZARD					
	AVALANCHE	SLOPE FAILURE			FLOODS (RIVER) EROSION	WIND & ICE LOADING
		EARTH-FLOW	DEBRIS-MUD FLOW	ROCK-FALL		
39-45	I	II	II	I	II	II
40-41	I	II	II	I	II	II
40-56	I	II	II	I	II	II
41-56	I	I	I	I	I	II
42-43	I	II	II	II	II	II
43-46	I	I	I	I	I	II
43-47	I	I	I	I	I	II
44-58	I	II	II	I	II	II
45-46	I	II	II	I	I	II
45-58	I	II	II	I	II	II
45-60	I	II	II	II	I	II
46-47	I	I	I	I	I	II
47-48	I	II	I	I	II	II
48-49	I	II	II	II	I	II
49-59	I	II	I	I	I	II
49-60	I	II	II	II	I	II
49-50	I	II	II	II	I	II
50-51	I	II	II	II	I	II
51-52	I	I	I	I	II	II
51-55	I	II	I	I	I	II
53-54	I	II	I	I	I	II
53-55	I	II	I	I	II	II
58-60	I	II	II	II	I	II

*230 kV T/L ONLY

NOTES:

1. FOR EXPLANATION OF EVALUATION SYSTEM REFER TO TABLE 4-4 (SECURITY EVALUATION TABLE)

BC Hydro

STIKINE - ISKUT
HIGH VOLTAGE TRANSMISSION SYSTEM
SECURITY RATINGS TABLE

DATE	TABLE 4-5
DWN	DWG No SHEET 2 OF 2

SECTION 5.0 - ROUTE AND SCHEME COMPARISONS

5.1 INTRODUCTION

(a) Segment Evaluation

This report has considered, through six schemes, over 3900 km of potential transmission line routes to establish route preferences that best satisfy the technical requirements of integrating a high voltage transmission system from the Stikine River, Iskut River and More Creek hydroelectric generation sites with the existing B.C. Hydro electric system.

It has been determined that some route segments must be used regardless of which scheme for integrating Stikine-Iskut power is selected. For the remaining segments, where alternatives were available, the following discussion describes the most acceptable segments based on the technical, cost and hazard evaluations. It then compares the schemes and establishes the scheme and associated route preference overall.

A more extensive evaluation of route segments will be necessary when a scheme is selected and an alignment is chosen within that scheme. The information provided here is to explain the preference for one segment over another and the ultimate selection of one scheme over the others.

5.2 ROUTE COMPARISONS

(a) Scheme I

1. Iskut River route (2-3-4) vs. Kakiddi Creek route (2-4) (see Plate 3-1, Sheet 1) - Although segment 2-3-4 has a slightly higher ice and wind rating the route is in the proximity of Highway 37 which would be beneficial for construction, maintenance and in the case of an outage or interruption. Segment 2-3-4 is the longer of the two but is less expensive due to the available access. Therefore, the Iskut River route along segment 2-3-4 is selected as the preferred technical choice.

2. Iskut Canyon and Snowbank Creek Route (9-8-7-5-14-13) vs. Unuk River and Treaty Creek Route (9-10-11-12-13) - The avalanche hazard along segment 5-14 is considered to be as severe as that along segments 9-10-11-12-13, however, the good linear access provided by Highway 37 would greatly assist transmission line maintenance and drastically reduce the length of any outages which may be experienced. In addition wind and snow loadings are expected to be less along the more sheltered low elevation segment 5-14 compared with segments 9-10-11-12-13.

   The difficult access and clearing conditions in segments 9-10 and 11-12 also contribute to the undesirability of Section 9-13.

   Therefore the Snowbank Creek, Ninqunsaw and Bell-Irving rivers route along segments 5-14-13 is selected as the preferred technical choice.

To Telkwa Substation

3. Bulkley Valley route (21-30-41-32) vs. Kitwanga River route (21-22-26-29-31-32) - The Bulkley Valley segment has slightly lower hazard ratings than the Kitwanga River segment and similar technical ratings. However, the Bulkley route is longer and as a result more expensive. More deflection angles and an additional major river crossing also add to the cost of the Bulkley River valley route as compared to the Kitwanga River route. Therefore the Kitwanga River route to Telkwa substation along segments 15-21-22-26-29-31-32 is selected as the preferred technical choice.

To Skeena Substation

Section 3.4(a)(viii) describes the five alternative routes to Skeena Substation from the common point 15 near Meziadin.

4. The first route along the White and Kinskuch rivers (15-16) is a wide valley rated low for hazards but limited access marginally increases the cost of construction. As the route continues adjacent to the existing 138 kV transmission line and the Tseax River (16-17-18), there is little threat from slides or avalanches. However, the proximity of the Kitsumkalum River could present a flood hazard. Access is very good through the Kitsumkalum valley portion.

5. The second route following the Nass, Kiteen and Cedar rivers (15-19-20-17) is a desirable route between 15 and 19. The access is excellent in this portion and rolling, open terrain poses few hazards. However, the Kiteen River valley (19-20) has steep slopes, little existing access and shows signs of several avalanches.

The slope failure rating is high due to the unstable soils along the river. This instability could be aggravated by logging and transmission line clearing. The pass between the Kiteen and Cedar rivers may experience moderate icing, high winds and snow slides. The threat of soil movement and avalanches make this an undesirable transmission line route.

6. The third alternative (15-19-16-17-18) using segment 19-16 combines the accessible, secure, easy terrain of the Nass River route with the accessible, secure easy terrain of the Tseax and Kitsumkalum rivers route.

7. The fourth route starting at point 22 and following the Skeena River has high ratings for earthflow, mudslides and flooding potential. This is due to the steep valley sides and narrow canyon in the southern section. Access to the line would be difficult to build despite the access provided by Highway 16. A land use conflict could develop on this route because Highway 16, the Canadian National Railway, Skeena River, townsites and the existing transmission line near Terrace, are all confined to the same valley.

8. The fifth alternative to Skeena Substation starting at point 26 and following the Zymoetz River is rated low in hazards to point 27. From 27-24 the route would follow less stable locations than the existing line. The transmission line would also cross potential mining property in this area.

   The route along Williams Creek (27-28-25) would be exposed to less severe hazards although careful placement to avoid avalanches is necessary.

The fifth alternative is nearly 80 km longer than the Tseax and Kitsumkalum rivers route and 40 km longer than the Skeena River route.

Therefore the Nass, Tseax and Kitsumkalum rivers route along segments 15-19-16-17-18 is selected as the preferred technical choice.

(b) Scheme II

1. Stikine Collector to Muckaboo Collector - Segment 2-3-34 is followed because it is 5 km shorter than segment 2-34 and less expensive due to some available access. It also avoids the unstable slopes adjacent to the proposed reservoir.

2. Iskut Canyon to Muckaboo Collector - There is only one route from Iskut Canyon to Muckaboo Collector that avoids building along Highway 37 but the inherent hazards should be noted. An evaluation of segments 9-10-11-12-13 is given in Section 5.2(a), Scheme I,2. which also describes the alternate route north along the Iskut River and south down Snowbank Creek. Therefore, the route following the Iskut River and Snowbank Creek (segment 9-8-7-5-14-13) is selected as the preferred technical choice to point 13.

   A transmission line along segment 13-36 would require numerous deflection angles. The severe rating for ice and wind loading is due to the high terrain near the headwaters of Taft Creek. High moisture levels in the air from the coast could combine with the cold air here to cause heavy ice loads on the conductors. Clearing and access are rated high because remaining forest cover is thick and there is no access.

Careful tower placement would be necessary to avoid avalanche paths. However, this is the only acceptable route available to reach Muckaboo Collector from point 13.

3. Muckaboo Collector to Telkwa Substation - The majority of the security ratings are similarly low for all five options except for segment 39-42 which was rated high because of slope failures in the pass between the Sicintine and Shelagyote rivers.

The shortest of the five optional routes from Muckaboo Collector to Telkwa Substation is the option (36-37-39-40-41-32) through the Bulkley Valley. However, the difference in length between any of the routes is negligible. The greatest amount of access construction would be required on the most easterly route option (36-37-39-45-46-43-32). The two southerly options passing through the Kispiox and Bulkley river valleys require less access construction and the option passing through the Kitwanga River valley requires the least. The Kitwanga River option (36-38-57-21-22-26-29-31-32) is also the least expensive following Kotsinta Creek and the Nass, Kitwanga and Kitseguecla rivers. Therefore the Kitwanga River route along segments 36-38-57-21-22-26-29-31-32 is selected as the preferred technical choice.

(c) Scheme III

As discussed, Scheme III is similar to Scheme I except the transmission lines from Iskut Canyon and More Creek generating stations are directed to Telkwa Substation instead of Skeena Substation. An additional line is then required between Telkwa Substation and Skeena Substation. The three transmission lines between Bob Quinn Collector and Telkwa Substation follow the same preferred technical route segments chosen in Section 5.2(a) Scheme I.

The only additional route segment comparisons introduced by Scheme III are for a transmission line between Telkwa and Skeena substations.

Existing Transmission Line Route (32-31-29-59-27-24-25-18) vs. Burnie River Route (32-31-33-28-25-18) - Both of these routes show similar terrain and forest cover densities. The existing transmission line (circuit 5L63) route has the advantage of known terrain problems and existing access. Also, it is desireable to avoid the congested area near Terrace. Therefore, a combination of the two routes following segments 32-31-29-59-27-28-25-18 is selected as the preferred technical choice.

(d) Scheme IV

Scheme IV is similar to Scheme II except the transmission lines from Iskut Canyon and More Creek generating stations are directed to Telkwa Substation instead of Skeena Substation. An additional line is then required between Telkwa and Skeena substations. Therefore, the transmission lines between the possible Muckaboo Collector and Telkwa Substation follow the same preferred technical route segments chosen in Section 5.2(b) Scheme II except for a short segment between point 13 and 30 where the second transmission line from Iskut Canyon meets the transmission lines from Muckaboo Collector. If a route east of the Kitseguecla or Bulkley river valleys is chosen then both lines from Iskut Canyon would have to continue to Muckaboo Collector in order that all three lines proceed to Telkwa Substation on common right-of-way. The prospect of threading two transmission lines through the Taft Creek valley would significantly lower the overall security of this scheme from a system perspective. The cost also increases due to the additional length of transmission line construction required.

The preferred technical route segments between Telkwa and Skeena Substations are those chosen in Section 5.2(c) Scheme III.

(e) Scheme V

BCR route vs. South route - The evaluation of both these routes suggests that neither could be recommended over the other based on transmission line security. Both routes traverse wide, rolling valleys where the terrain is interspersed with numerous swamps and lakes. There is a moderate threat of avalanches and slope failures in segment 35-44 on the BCR route and 39-42 on the south route. The very low rating of all hazards should be noted on the south route segments 43-47 and 53-51 and the connecting segment 46-47. Access construction appears to be difficult on the Nass River portion of the south route while the BCR route has established access along the Skeena River. However, some hand clearing and difficult river crossings are evident on segment 49-50 of the BCR route. The least expensive route appears to be a combination of the BCR route following the Skeena River along segments 35-58-45; the connection following the Squingula and Nilkitkwa rivers along segments 45-46-47; and the south route following Tochcha Lake and Sutherland River along segments 47-53-51-52. Therefore the Skeena, Squinqula, Nilkitkwa and Sutherland rivers route along segments 35-44-58-45-46-47-53-51-52 is selected as the preferred technical choice.

(f) Scheme VI

Scheme VI is similar to Scheme V except the transmission lines from Iskut Canyon and More Creek generating stations are directed to the proposed Stikine Collector and Cluculz Station instead of Skeena Substation. An additional line is then required between Telkwa and Skeena substations to provide backup power to the Terrace-Prince Rupert area. Therefore, the three lines between the proposed

Stikine Collector and Cluculz Station follow the same preferred technical route segments chosen in Section 5.2(e) Scheme V.

The preferred technical route segments between Telkwa and Skeena substations are those chosen in Section 5.2(c) Scheme III.

5.3 SCHEME COMPARISON

In Schemes I through IV the triangular region bounded by the Bob Quinn Collector, Iskut Canyon dam and the Bell-Irving River/Taft Creek confluence is considered to have the lowest overall security. However, the avalanche hazard through these regions was assessed and it was concluded that reasonably secure tower sites could be selected. Good access is provided by Highway 37 to the route between Bob Quinn Collector and the Bell-Irving River/Taft Creek confluence. Total hazard exposure in this area is reduced in Schemes I and III by avoiding the unaccessed, high elevations of segments 9-10-11-12-13.

Schemes II and IV combine the uncertain security of segments 9-10-11-12-13 from Iskut Canyon to the Bell-Irving River/Taft Creek confluence with that of the Taft Creek segment and its potentially unstable soils and possible wind/ice conditions. This is especially true in Scheme IV if two transmission lines must be routed through the Taft Creek valley to the possible Muckaboo Collector.

There appear to be few security hazards along the routes chosen in Schemes V and VI but their extreme length increases the potential for outages and makes these schemes unattractive economically.

Other security hazards exist throughout the study area but are minimal relative to the total distance of over 3900 km of route segments analyzed. The security assessment concludes that based upon sound

engineering judgement and experience with transmission line construction and maintenance a system with acceptable security could be installed.

The transmission routes which best satisfy the technical requirements for each of the six schemes evaluated in this report are summarized in Table 5-1.

Of the six schemes presented, Scheme I would require the least capital cost. It is $474 million less expensive than Scheme II, $247 million less than Scheme III, $732 million less then Scheme IV, $1.13 billion less than Scheme V and $2.11 billion less than Scheme VI. This economic comparison considers 500 kV construction costs. Construction of a higher voltage transmission system would further increase the cost of Schemes V and VI. Relative costs of the six schemes are dependent on the routes selected and will vary from those shown in Table 5-1 if routes or route segments change from those shown.

Scheme I results in the smallest amount of new transmission line construction. This scheme would result in 1479 km of transmission line construction compared with 1648 km for Scheme II, 1653 km for Scheme III, 1822 km for Scheme IV, 2022 km for Scheme V and 2657 km for Scheme VI. It should be noted that the exact length of the routes would vary depending on the precise alignment selected within each route.

SCHEME	ROUTE SEGMENTS	ROUTE LENGTH (km)	TOTAL LENGTH OF TRANS. LINES (km)	TOTAL DIRECT TRANS COST ESTIMATE x $1000	TOTAL DIRECT STATION COST ESTIMATE x $1000	TOTAL SCHEME COST ESTIMATE x $1000	REMARKS
1	1-2-3-4-5,5-6,9-8-7-5, 5-14-13*-15-21-22-26-29-31-32,15-19-16-17-18	787	1479	607736	103370	3059031	Least cost alternative.
2	1-2-3-34-35-36,6-8-9, 9-8-7-5-14-13-15-19-16-17-18,13-36-38-57 21-22-26-29-31-32	1002	1648	686054	85870	3532781	$474 Million more than least cost alternative.
3	1-2-3-4-5,5-6,9-8-7-5, 5-14-13*-15-21-22-26-29-31-32,32-31-29-59-27-28-25-18	693	1653	653816	109190	3306271	$247 Million more than least cost alternative.
4	1-2-3-34-35-36,6-8-9, 9-8-7-5-13-15-21,13-36, 38-57-21-22-26-29-31-32,32-31-29-27-28-25-18	956	1822	734639	103490	3790960	$732 Million more than least cost alternative.
5	1-2-3-34-35-44-58-45-46-47-53-55-51-52, 6-8-9,9-8-7-5-4-3-2, 9-5-14-13-15-19-16-17-18	1237	2022	797777	136020	4187218	$1.13 Billion more than least cost alternative.
6	1-2-3-34-35-44-58-45-46-47-53-55-51-52, 6-8-9,9-8-7-5-4-3-2, 32-31-29-27-28-25-18	1044	2657	989236	168740	5163985	$2.11 Billion more than least cost alternative.

*SEGMENT CONTAINS 1-DOUBLE CIRCUIT AND 1-SINGLE CIRCUIT TRANSMISSION LINE

NOTES: 1. THE TOTAL ROUTE LENGTHS AND COSTS SHOWN FOR EACH SCHEME WILL CHANGE IF OTHER ROUTE SEGMENTS ARE USED TO SATISFY THE SCHEME.

2. COSTS IN 1981 DOLLARS.

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HIGH VOLTAGE TRANSMISSION SYSTEM

ROUTE COMPARISON TABLE

TABLE 5-1

SECTION 6.0 - CONCLUSION

It is recommended that hydroelectric power generated on the Stikine River, Iskut River and More Creek be integrated with the existing B.C. Hydro transmission system with a transmission network as outlined in Scheme I of this report. This scheme provides for a collector near More Creek designated as the Bob Quinn Collector. Power collected at Bob Quinn from the four generating stations would be transmitted to the existing Telkwa and Skeena substations using two - 500 kV transmission lines to Telkwa and one - 500 kV transmission line to Skeena. Recommended routes as shown on Plate 6-1 would generally follow existing access along the Iskut and Bell-Irving rivers to a point near Meziadin in the Nass River valley. From the Nass River the route to Telkwa Substation would use the valleys of the Cranberry, Kitwanga and Kitseguecla rivers and remain west of Hudson Bay Mountain. The route to Skeena Substation near the city of Terrace would use the valleys of the Tseax and Kitsumkalum rivers.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

STIKINE - ISKUT

HIGH VOLTAGE TRANSMISSION SYSTEM PREFERRED TECHNICAL ROUTES

DATE	PLATE 6-1
DWN	DWG No

APPENDIX A
SURVEY AND CONSTRUCTION PROCEDURES

A.1 SURVEY

To determine the feasibility of a particular route, centreline survey is sometimes necessary. This may be required before the route has been approved or a precise alignment established. After the route has been selected and approved, Engineering Survey can start.

This survey is performed in three main stages. The first stage is the establishment of horizontal and vertical ground control which is done after a detailed route has been selected and approved. Control can be established either photogrammetrically or conventionally whereby the coordinates of the main deflection points along the alignment are determined and established in the field.

The second stage involves the cutting of a centreline along the proposed route and the production of a profile along the centreline. Access to the line by the survey crews would generally be by road, where available, otherwise by helicopter.

The final stage in the engineering survey would be the establishment and staking of the individual tower sites. This would be performed after the line has been designed in the office and the location and the type and height of the structures has been determined.

A.2 ACCESS

The subject of access is best described in the B.C. Hydro Engineering Standard No. ES-41-E0001-01-R00 titled "Transmission Line Right-of-Way Access Policy." The following are excerpts from this standard.

> "The intent is to supply access at the lowest possible cost with a minimum of ground disturbance for logging, clearing, construction and maintenance of a secure transmission line system. Other possible uses of the access system are secondary."

The characteristics of each project, and its sub-areas, will be considered on their own merits to achieve controlled progressive development of access through the various stages of a transmission line project. Access will usually be by ground means. Aerial and water access will be considered in special circumstances.

> "Development of any access will be carried out to meet environmental constraints identified for the project. In assessing access requirements, the project characteristics mentioned below together with the environmental constraints will be taken into consideration, existing ground access including possible improvement will be evaluated, possible locations for new access will be investigated and strategy will be developed to ensure that appropriate access is established for the project.
>
> 1. Type and location of structures.
> 2. Terrain and soil conditions.
> 3. Land ownership and the rights of holders of lesser interests in land.
> 4. Presence, or otherwise, of merchantable timber.

Photo A-1

Machine cleared right-of-way. Note waste material piled to be burned.

5. Planned future development within the right-of-way.
6. Externally imposed requirements.

The standards pertaining to access construction will be specified in clearing and construction contract documents."

A.3 CONSTRUCTION PROCEDURES

(a) Logging and Clearing

The first major step in the preparation of the right-of-way on Crown land may be the logging of timber deemed merchantable by the Ministry of Forests (MOF). The logging operation and specific logging requirements are controlled and administered by the MOF and are carried out by logging companies. The logging generally requires the construction of logging roads and landings.

When the logging is completed the clearing operation begins. This involves removing the remaining forest cover which could be a hazard to the transmission line. The amount and width of clearing is determined by slope, conductor height, species and growth rates of the forest cover. For example, in areas with short, slow growing trees the clearing boundaries may be inside the legal right-of-way boundary. In areas with tall timber and steep side slopes the clearing boundary may be outside of the right-of-way. In some areas where the conductor is well above the average tree height, particularly across gullies and streams, no clearing is required. Some topping of trees in selected areas may also be carried out. In areas of recent logging activity very little or no clearing is usually required.

The methods to be utilized during the clearing operation are specified by B.C. Hydro in accordance with the land owner or Crown. The methods vary depending on terrain, slope stability, erosion potential and proximity to environmentally sensitive areas.

In areas near swamps, watercourses or on steep slopes where there is a high erosion potential, which would be increased by the use of motorized equipment, clearing is accomplished by hand held equipment. In these areas all taller trees are felled. Conifers less than 2 m in height and low growing vegetation which will not grow to 5 m at maturity are not cut. The larger trees are limbed and left lying flat on the right-of-way. Material under 15 cm diameter is piled and burned.

In areas which require hand clearing due to their sensitivity but also require that large debris be removed because of aesthetics, possible watercourse pollution or fire hazard, the larger material is removed using cable yarders, rubber-tired grapple loaders or rubber-tired skidders.

In areas which have a gentle slope, good drainage and stable soil conditions, clearing is accomplished by grubbing all brush and trees under 60 cm in diameter by bulldozer or similar equipment. Trees larger than 60 cm in diameter are hand felled. The waste material is piled and burned.

In areas where there have been specific requests by owners for stump removal and right-of-way grooming, and where there is no erosion potential, all the waste material may be removed by bulldozer.

Photo A-2

The installation of an earth grillage with a hydraulic back hoe on right of photo. A tank drill drilling for a rock foundation on the left.

(b) Foundation Installation

After the right-of-way has been cleared and the structures staked, foundation installation begins. Depending on schedule, working conditions and number of crews, foundation installation can begin at various points along the line. Separate crews are generally used for access road construction, site preparation and for the different foundation types to be installed e.g. earth grillages, rock footings, piles, etc.

The first step in the foundation installation is site preparation. Major equipment used for this operation are crawler equipped bulldozers and backhoes.

After the site has been prepared, excavation for grillage foundations is done by rubber-tired or crawler equipped backhoes. Crawler equipped tank drills, compressors and hand held rock drills are used for drilling rock anchors and for blasting shallow depth rock at grillage sites.

Components for grillage foundations are usually stored and assembled at temporary yards set up along the length of the line. The assembled grillages are then delivered to the site, positioned in the excavation, and the earth backfilled and compacted around them.

Rock and concrete footings are constructed on site. Concrete for the footings can be made at portable batch plants set up along the route or purchased from local suppliers.

Pile foundations, which are most often required in wet and swampy ground, are large and require heavy equipment for installation. The major components are timber piles capped by concrete. The piles are driven with large truck-mounted or crawler cranes equipped with leads and drop hammer.

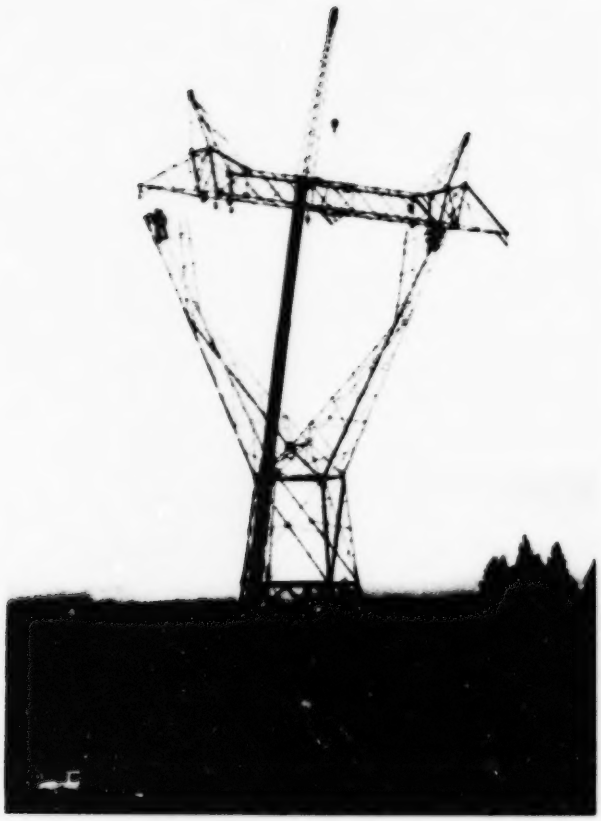


Photo A-3

A self supporting structure being erected by a crane.

Construction materials are delivered to the site by various means. Flat bed trucks are utilized for transporting assembled grillages, other foundation components and equipment. Concrete may be delivered by large transit mix trucks.

Foundation materials, concrete, small equipment and construction crews can be transported to otherwise inaccessible sites by helicopter. The maximum weight normally lifted by the largest, readily available helicopters in Canada is in the order of 2300 kg depending on elevation, weather conditions and distance from assembly area to work site. This limits a single load to approximately 1 m^3 of concrete. Equipment required for site preparation often has to be disassembled to permit transportation by helicopter. For these reasons helicopter operation is usually not economical for foundation installation.

(c) Tower Erection

The next major phase of transmission line construction is tower assembly and erection. Depending on scheduling and other factors, this phase of the work may or may not be carried out by the same contractor who installed the foundations. Nonetheless, the two operations are usually carried out separately.

The first step in tower erection is the local improvement of access and work areas at individual tower sites to handle the different types of equipment used for tower erection.

Tower steel is delivered to temporary steel yards established at the nearest rail siding, highway or road access along the route from where the steel is sorted and distributed to the tower sites by various means, the most common of which is crane equipped, flat-bed trucks.

Photo A-4

Structure erection utilizing a helicopter.

Tower components are generally assembled on site by crews working ahead of the tower erection crews. The tower components are assembled utilizing 15 to 20 t cranes.

Tower erection is carried out by use of large truck-mounted hydraulic cranes which have capacities of 35 to 65 t. Cranes of this size are cumbersome and thus require bulldozers to aid in maneuvering and for preparation of working areas.

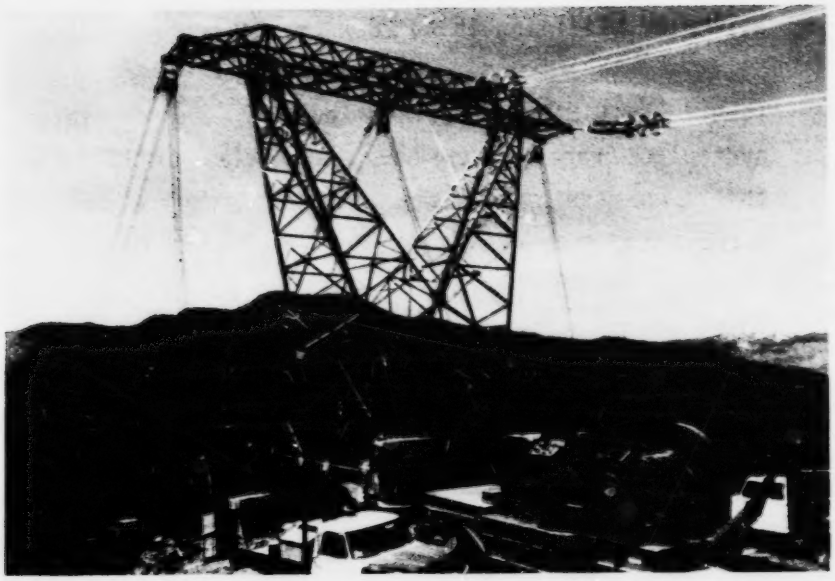
Tower erection on difficult or environmentally sensitive areas can be accomplished by helicopter but this method has similar limitations as discussed earlier for foundation installation.

The main limitation to helicopter erection is the weight of the towers. The towers to be used on the project weigh between 20 000 and 68 000 kg. Whole towers cannot be erected with a single lift. Individual tower components must be assembled and flown into place component by component. To optimize the economics of this operation, assembly yards would be placed at 10 to 15 km intervals along the route where assembly can be accomplished by conventional means for later delivery to the tower site by helicopter. Assembly yards should be accessible by road. Regular spacing of assembly yards along the route is required to minimize the flying time to the individual tower sites.

Weather conditions, helicopter availability, economies of scale (i.e. number of towers to be erected) are all factors which limit the use of helicopters for tower erection.

(d) Conductor Stringing

Conductor stringing, like foundation installation and tower erection, is usually done under a separate contract. This phase of



Photos A-5 and A-6

The equipment necessary for conductor stringing.

construction is complex involving stringing, sagging, clipping, dead-ending and spacing the conductor.

Large specialized equipment such as line pullers and tensioners are required for the stringing operation. This equipment cannot be lifted by helicopter and requires good road access. However, this equipment is only needed at intervals along the line. The spacing of these "set up" intervals is generally limited by the length and weight of conductor on each reel.

The conductor is pulled between the set ups by first stringing a small diameter line through sheaves on each tower. This operation is usually done by helicopter. This line is then used to install the main pulling line which in turn is attached to the conductor. The conductor in turn is pulled through by the line puller at the destination end. The conductor is kept under tension at the reel end to avoid damage by contact with the ground or obstructions.

After the conductor has been strung it is sagged to a specified tension and connected to the insulator assembly on the tower.

Cranes, forklifts, specially equipped caterpillars and all-terrain vehicles are used for handling materials, hanging insulator assemblies and other stringing operations. Material yards are established at various intervals along the route.

(e) Office and Accommodation

Temporary office facilities and construction camps will be required at several intervals along the route because the rugged terrain and difficult access would otherwise cause excessive travel time to and from the work sites.

The specific size, type and location of the facilities will vary with each phase of construction and will be dependent on the contractor's needs. Commercial facilities will be used wherever practicable.

APPENDIX B
GLOSSARY OF TERMS

Acceptable Route	-	A route that is technically feasible and economically viable.
Alignment	-	The proposed centreline for the transmission line right-of-way prior to survey.
Capacitor Station	-	An electrical station placed on a transmission line to improve voltage levels and increase power transfer.
Centreline Survey	-	The procedure of establishing the precise location of the proposed transmission line centreline on the ground and to determine a topographic profile for design purposes.
Circuit	-	A system of conductors through which an electric current passes.
Clipping	-	The procedure of fastening the conductor to insulator strings during the stringing operations.
Collector Station	-	An electrical station used to combine power from two or more generation sources by means of transmission lines.

Conductor	-	This is a cable or wire used to carry electricity. It is usually made of aluminum or aluminum and steel. It is supported by the transmission towers.
Dead Ending	-	The procedure of cutting and attaching the conductors directly to each side of the transmission tower using deadend hardware and insulators.
Deflection	-	A point where the direction of the transmission line changes.
Double Circuit Construction	-	The type of design used to place two separate transmission circuits on a single set of transmission towers.
Drumlin	-	An elongate or oval hill of glacial drift.
Feasible Route	-	See Acceptable Route
Interest During Construction	-	Interest charges incurred during the construction of a major project, which consist of the accumulated interest costs for borrowed funds used to pay the year by year construction expenditures before the project enters service and begins earning revenue.
Logging	-	The removal of merchantable timber from the transmission line right-of-way prior to clearing.

Riprap	-	A protection device usually constructed of large rocks to protect towers from erosion by water or earthflow.
Route	-	A linear area of land of indeterminant width within which one or more right-of-way alignments could be located.
Sagging	-	The procedure of measuring conductor dip between towers to maintain ground clearance.
Stringing	-	The procedure of placing the conductors on the transmission towers.
Substation	-	An electrical station which converts a transmission line at one voltage to a transmission line at another, usually lower, voltage (e.g. 500 kV to 138 kV).
Switching Station	-	An electrical station used to divert electricity from one transmission line into a different transmission line.
Transmission	-	A system for transporting or conveying electricity in bulk to convenient points where it may be stepped down in voltage for delivery to customers via a distribution network.
Unacceptable Route	-	A route with length, environmental impact or exposure to hazards such as to require excessive expenditures to attain a reasonably secure transmission line.

POOR

QUALITY

ORIGINAL